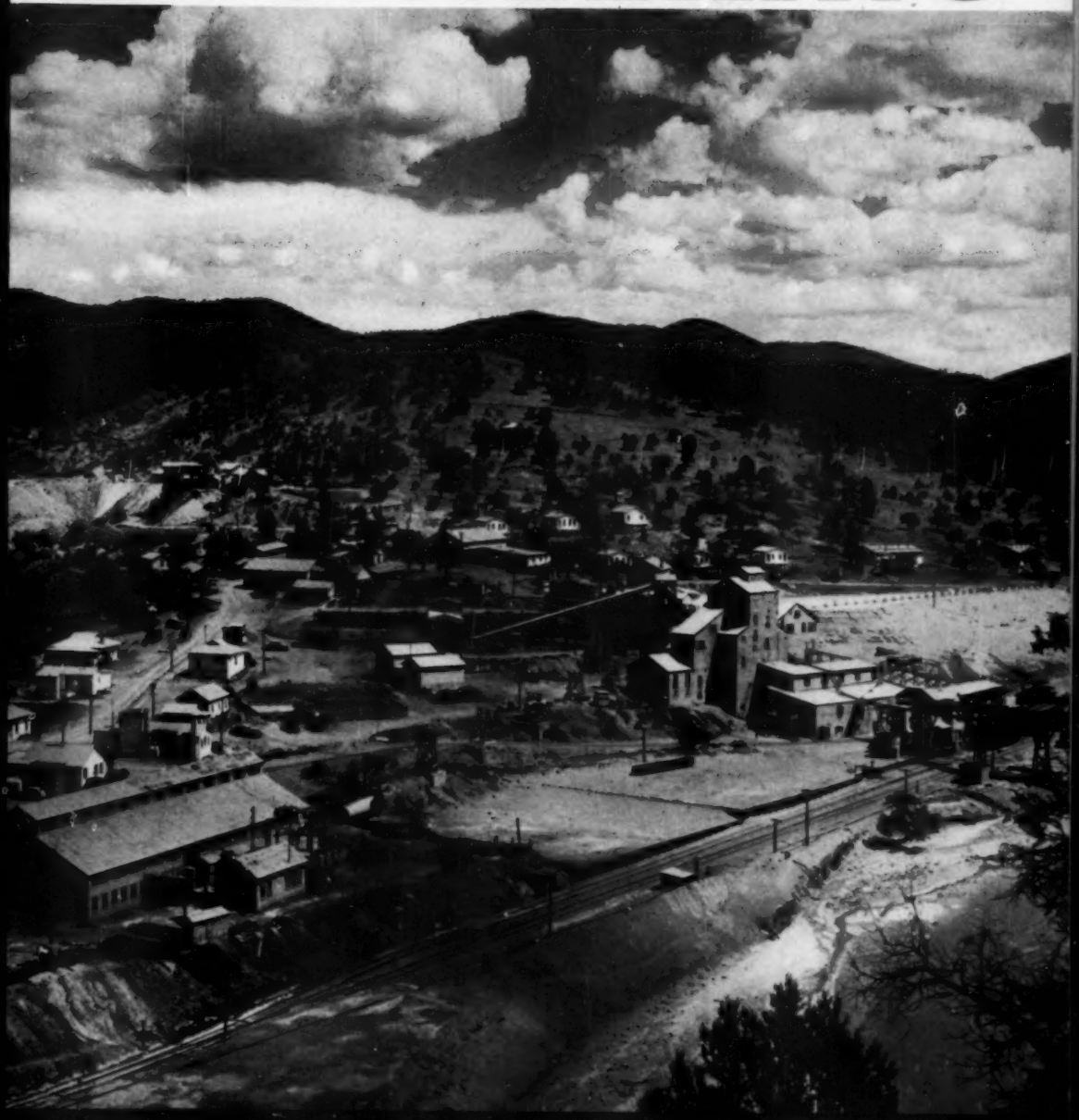
MINING ENGINEERING

FEBRUARY 1951



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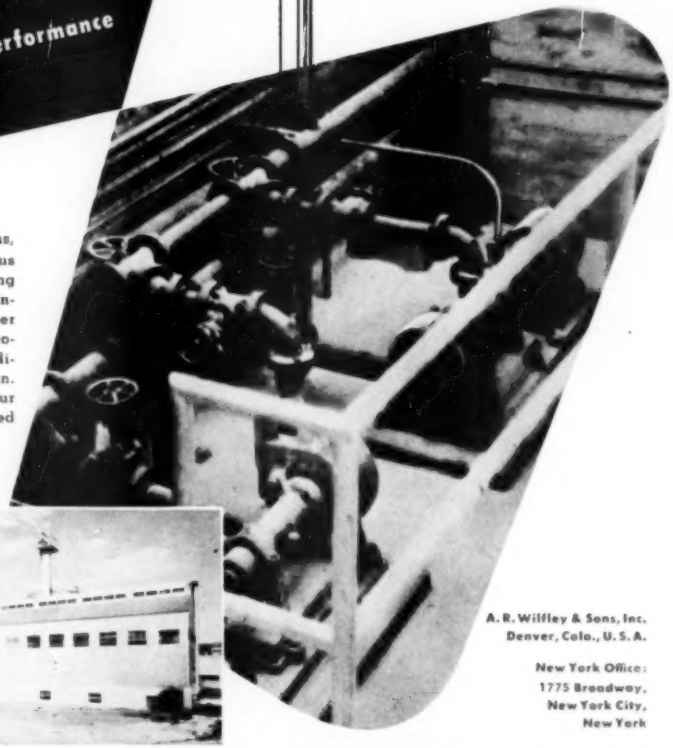

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Incorporating Mining and Metallurgy, Mining Technology and Coal Technology

VOL. 190 NO. 2 FEBRUARY, 1951

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FEATURES

Reporter 105
Editorial 107
Washington By-line 109
Sampling the Mining News 141
AIME News 185
Drift of Things 190
Coming Events 195
Manufacturers' News 142
Books for Engineers 144

Special Section: "AIME Salutes . . ." 145

ANNUAL REVIEW — 1950

Nonferrous Metals 110
Geology 113
Metal Mining 118
Beneficiation 122
Coal 126
Industrial Minerals 129
Mine Safety Makes Progress 133
Geophysics 136

TRANSACTIONS

Classification and Desliming with Liquid-Solid Charleston Cyclone 153
Graphite of the Passau Area, Bavaria 166
Rock Hardness as a Factor in Drilling Problems 173
A Pattern for Sound Fuel Procurement 177
Coal Preparation in England and Holland 183

COVER: The Hanover, N. Mex., operation of the New Jersey Zinc Co. is one of the mines working against time to keep up with an emergency demand for zinc. Near the Mexican border, Hanover is in the Hurley, Bayard, and Silver City area.

Personnel Service 86
Professional Services 198
Advertisers Index 200

UNDERGROUND, OR . . .

IT'S JOY EQUIPMENT

Right: The Joy Drillmaster, a versatile, self-propelled, highly maneuverable machine, gives you maximum footage at least cost per foot or hole. Features Joy Hydro Drill Jibs for fast, accurate hole positioning and remote control.

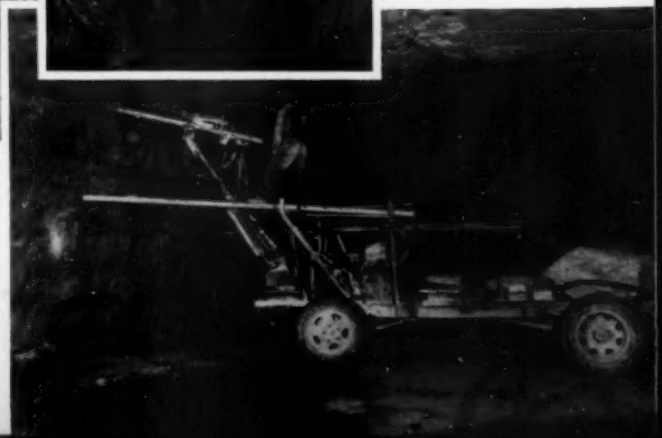
Above: For high-production loading and haulage of rock and ore, Joy teams of trackless loaders and electric or diesel shuttle cars get the call underground.

Right: Complete range of Joy Stopers includes the new S-91T, with telescopic feed. Requires fewer steel changes, gives more time for drilling.

Below: Joy Wagon Drill specially adapted to drill at any height from toe-holes to horizontals 9' high.

Left: The Joy HS-15 high speed drill for underground blast holes, or core drilling to 500'. Compact and easy handling, with "in-line" vibrationless drive.

Below: Joy Hydro Drill Jibs are versatile units; can be mounted as required to suit individual needs. This truck-mounted Jib is an example.



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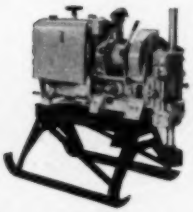
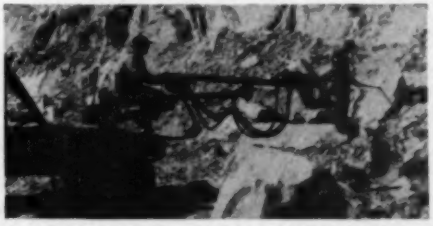
Above: Joy builds a complete line of "Silver Streak" Hand Tools, cadmium-plated for rust protection and easier running in.

Above: Joy Wagon Drills (Medium and Lightweight models) are easily maneuvered units with positive locking brakes for quick set-ups and balanced drilling on any terrain.

Above: Joy Champion Rotary Drills set absolutely new standards in high-speed, economical blast hole drilling, far outperforming all others. Built in two self-propelled models, for diesel, gasoline engine or electric motor drive.

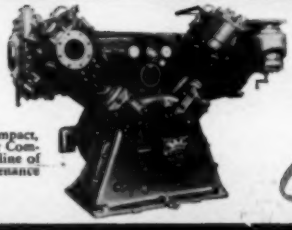


Above: Joy Core Drills range in capacity from 250 to 1750 feet of 1¾" hole. Screw feed or hydraulic types—gasoline, diesel, air or electric drive.



Left above: Joy's popular Series 80 Portable Compressors, with the famous "Econo-Miser" load control, are built in seven sizes, from 60 to 630 CFM.

Above: Joy Hydro Drill Jibs are readily adaptable to truck-mounting, etc. for secondary drilling or toe-holes in quarries or open-cut mining.



Right: Joy pioneered the compact, modern "package-type" Air Compressor—offers a complete line of highly efficient, low maintenance airplants up to 3656 CFM.

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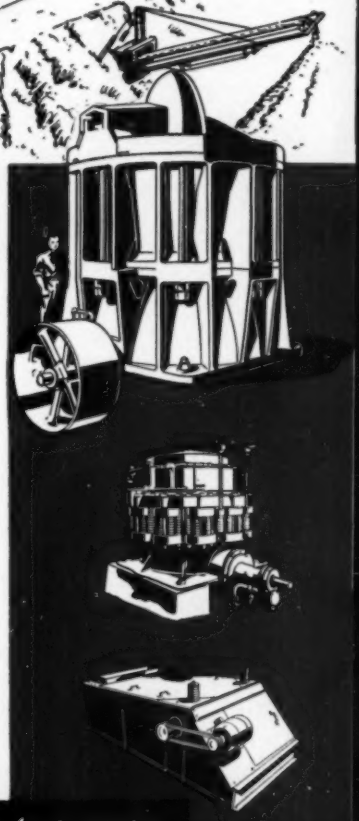

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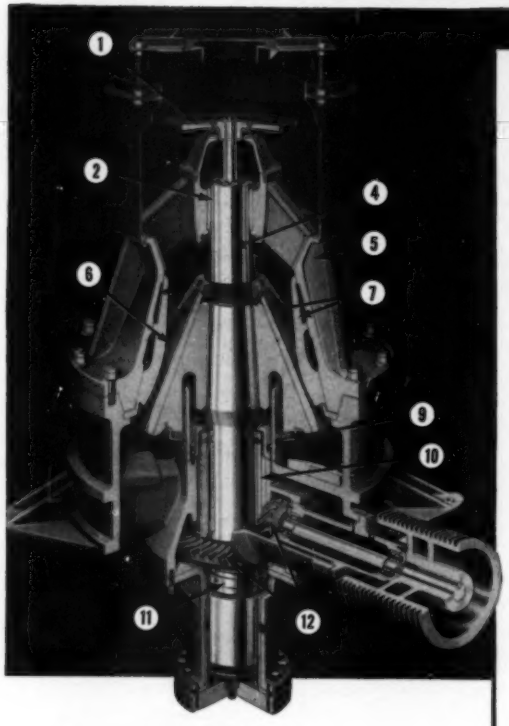

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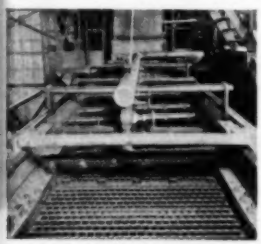

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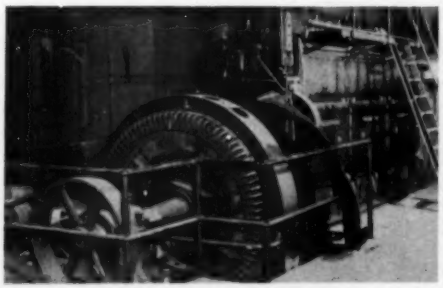

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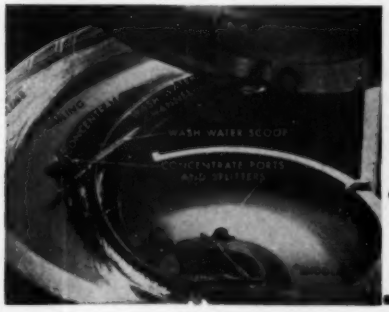

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SPIRATUBE-M and AYRTUBE cut Air Delivery Costs. Made specifically for mine and tunnel ventilation, these two new *AIRDUCTS* working individually or in combination, deliver a maximum cubic measure of air right at the working face and at the lowest possible cost—because—ease of handling reduces installation costs, and construction features minimize leaks and seepage. You get the full volume created by your fans and blower units right where you need it—at the working face—reducing power costs.

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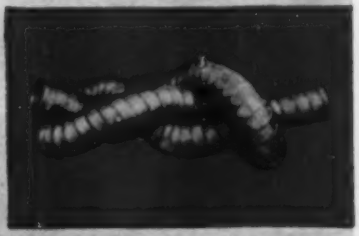

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Case histories prove longer life

These actual service tests, involving the crushing of millions of tons of ore, represent data on which you can rely. Years of service have confirmed the results of this carefully-run test.

Write for 32 pp reprint of an informative paper published by the Amer. Inst. of Mining and Metallurgical Engrs., giving results of wear tests on grinding ball materials—FREE!

Case No. 1

Tests in Colorado between 1938-40: Molybdenite ore—quartz and feldspar, principal abrasives.

Service: Marcy 9′ × 9′ Trunnion overflow type ball mills grinding minus ¾″ siliceous ore to 62% minus 100 mesh. Mill pump density 75% solids. Mill speed 20 rpm: balls charged were 3″ dia.

Comparison: Under similar conditions, between two sets of manganese steel liners and six sets of high carbon chromium-molybdenum steel, (normalised and tempered to average 360 brinell).

Liner type: Shell (Barrel liners), ship lap type; weight 33,500 lb. approx. per set.

Results:

	Hours in Service	Net Wear Lb/Hr*	Per cent Scrap
Manganese steel (average of two sets)	4979	4·59	34·2
Cr-Mo steel (average of 6 sets)	5561	3·97	34·3

* Net wear per hour represents metal actually worn away.

The manganese steel liners wore 16% faster than the chrome-molybdenum steel liners.

Case No. 2

Tests in Colorado, 1943: Molybdenite ore—quartz and feldspar, principal abrasives.

Service: Marcy 9′ × 8′ grate discharge type ball mills grinding minus ¾″ siliceous ore to 55% minus 100 mesh. Mill pulp density 75% solids. Mill speed 20 rpm: balls charged were 3″ dia.

Comparison: Under similar conditions between two sets manganese steel liners and eleven sets of high carbon chromium-molybdenum steel, (normalised and tempered to average 400 brinell).

Liner type: Shell (Barrel liners), ship lap type of special thin design for high capacity mill operation; weight 26,000 lb. approx. per set.

Results:

	Hours service	Net Wear Lb/Hr	Tons Ground	Net Wear Lb/Ton	Per cent Scrap
Manganese steel (Average of 2 sets)	2441	6·14	209824	·0715	38·7*
Cr-Mo steel (average of 11 sets)	3018	5·02	249002	·0616	42·8

*worn beyond desired limits.

The manganese steel liners wore 22% faster (per hour basis) or 16% faster (per ton basis) than the chrome-molybdenum liners.

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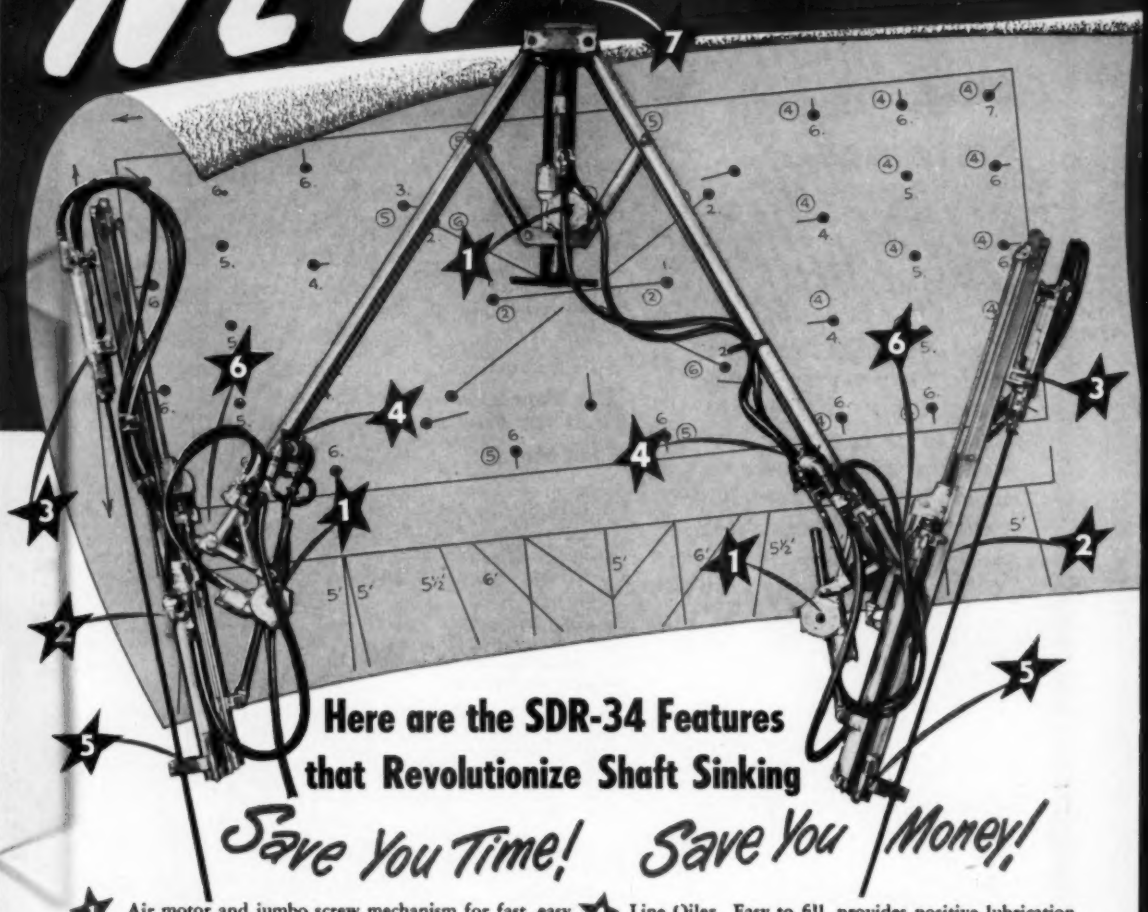


Here are the SDR-34 Features that Revolutionize Shaft Sinking

Save You Time! Save You Money!

1. Air motor and jumbo screw mechanism for fast, easy adjustments. No slippage — good, positive set-up for complete drilling round.
2. Patented 2-to-1 air feed cylinder with chain drive. Positive feeding action for maximum drilling speed, minimum bit-wear. Six-foot changes eliminate steel handling for increased footage.
3. Model H23 Sinker. Weight 83 pounds. 3" bore provides plenty of rotation power and force of blow for fast drilling in all types of rock. Chucks for: 1" hex x 4¼", 1" or 1¼" round lug or popular quarter octagon sizes.
4. Line Oiler. Easy to fill, provides positive lubrication to the machines.
5. Drill Steel Centralizer. Opens and closes quickly. Makes hole collaring faster and safer.
6. Holes can be drilled at any angle. Adjustments are made quickly and easily by MDR air motors. You get better breakage for faster mucking.
7. Complete self-contained unit. Reduces handling time and effort. Speeds up shaft-sinking cycle for lower costs.

Specifications

LE ROI-CLEVELAND SDR-34 MULTIPLE DRILL SHAFT SINKER

Weight	1900 lbs.
Width in closed position	5'6"
Length	14'
DB34 air-shell travel	7'
DB34 air-shell steel change	6'
H23 chuck size —	1" hex x 4½ shank
	1" or 1¼" round lug, or
	popular quarter octagon sizes

Can be furnished with 45 to 55 lb. Le Roi Cleveland H10 DR Drills—and for extremely hard rock conditions either the 3½-inch bore D-25 Drifter or the 4-inch bore D-14 Drifter.

SDR-34 Shaft Sinker

Drills 42-hole round in only 1/3 the time

required by two 55-lb sinker drills

Complete self-contained rig revolutionizes shaft sinking — speeds drilling — reduces steel handling — cuts costs!

HERE'S an example of how the new SDR-34 rig takes the headaches out of shaft sinking:

On a recent shaft job, the SDR-34 unit drilled out a 42-hole round (each hole 6 ft. deep) in less than an hour. On the same job it took two 55-lb. hand-held drills (3 steel changes) over three and a half hours to drill out this 42-hole round.

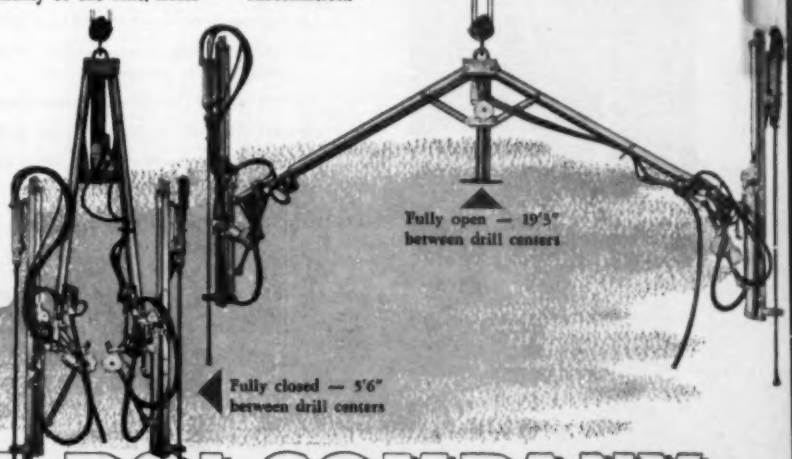
Obviously, savings such as this in drilling time do much to cut shaft sinking costs.

Moreover, because of the flexibility of the unit, holes can be drilled in the proper location and at the right angles to insure breakage for faster mucking. Again, you save!

Operators are less tired at the end of the shift, too. Using six-foot steels with tungsten carbide bits eliminates extra steel handling. And centrally located controls make the drill runner's job just that much easier.

Simplify your next shaft-sinking job with the SDR-34 and watch your costs drop! Write today for additional information.

The SDR-34 is a self-contained unit consisting of two famous Le Roi-Cleveland air-feed shells with two well known and popular Cleveland drills, air and water hoses, line oilers, drill-steel centralizers. Self-contained feature allows it to be dropped or withdrawn from shaft as a unit. Saves handling time. Gets round started faster for lower costs. MDR air motors make positioning fast, and easy — control arm-spread and drill angle through famous mine-jumbo screw mechanism.



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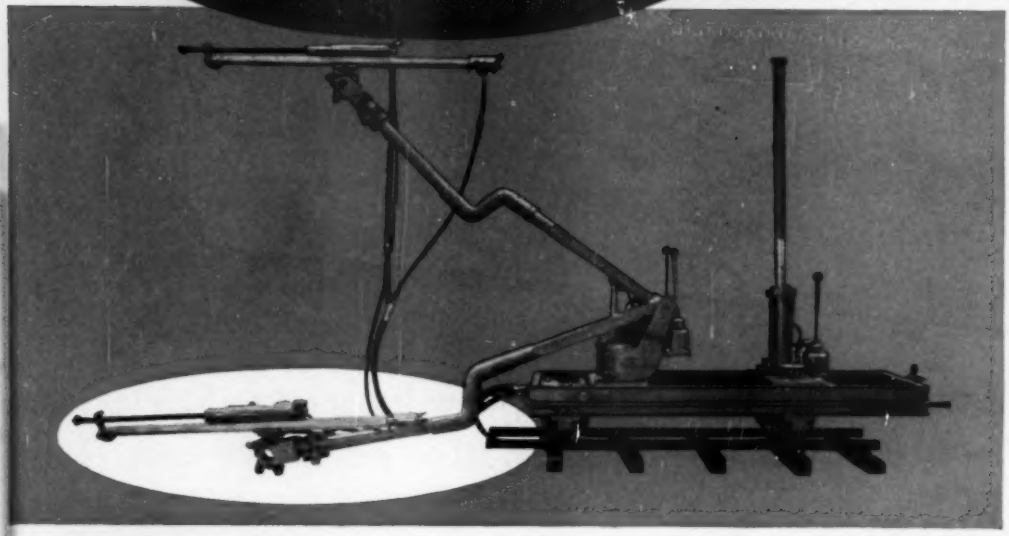
Complete truck-mounted units include hydraulic roof jack and either one, two or three drill booms.



Hydraulic boom and roof jack units are available separately for mounting on your own custom-built jumbo.

These offset booms are great time-savers when you're drilling the lifters. Your runner doesn't have to take time out to swing the drill under — steel is easily and quickly centered on *every* hole in the face.

And that's only one of the *many* big advantages of Gardner-Denver Hydraulic Drill Jumbos. Other features include:

- **Faster set-up—move in and start drilling.**
- **Faster tearing down—release hydraulic pressure and the jumbo's off to another heading.**
- **"Creep-free" booms—hold steel steady and true.**
- **Hydraulic roof jacks—hold truck on-the-spot.**
- **Handle long feeds—up to 10-foot steel changes—for efficient use of tungsten carbide bits.**

Write today for complete information.

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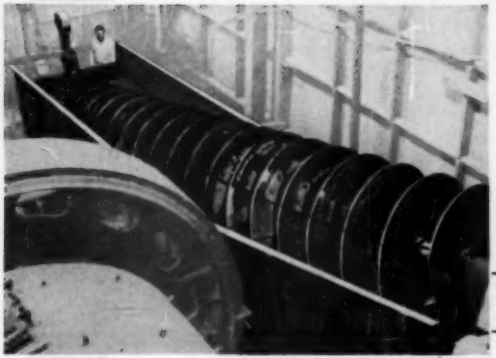
Actual Operating Results Prove Efficiency of **WEMCO S-H CLASSIFIER**

Sharp separation at large capacity is a proven result at the Fredericktown Mill of National Lead Company, St. Louis Smelting and Refining Division. In handling a lead-copper sulfide ore, a WEMCO S-H Classifier is more than meeting requirements for close separation (desired grind — 60% minus 200 mesh).

SHARP SEPARATION — From the table below note that this WEMCO S-H Classifier overflow analyzed 64.0% minus 200 mesh, showing a recovery of 88.1% of the minus 200 mesh material contained in the feed. Despite the high percentage of plus 65 mesh fraction in the classifier feed, only 4.5% was retained in the overflow. The sands, analyzing only 5.4% minus 200 mesh, contained 95.5% of the plus 65 mesh feed.



LARGE CAPACITY — Rate of overflow in this installation is 825 tons per 24 hours, exceptional capacity for a unit of this size (72" x 32' 0", Series 125, Straight Tank, Triple Pitch).

SCREEN ANALYSIS

WEMCO S-H Classifier at Fredericktown Mill, National Lead Company, St. Louis Smelting and Refining Division.

MESH	INDIVIDUAL PERCENTAGES RETAINED ON FEED	SAND (61.4% OF FEED)	OVERFLOW (38.6% OF FEED)	CUMULATIVE DISTRIBUTION OF FEED SIZES SAND	OVERFLOW
+65	51.2%	79.8%	6.0%	95.5%	4.5%
100	9.8%	8.9%	11.2%	89.2%	10.8%
150	5.8%	3.9%	8.9%	85.0%	15.0%
200	5.0%	2.0%	9.9%	80.7%	19.3%
-200	28.2%	5.4%	64.0%	11.9%	88.1%

THE S-H DESIGN

- **Greater capacity** of WEMCO S-H Classifiers is proven in operation — and explained by design. The S-H design permits use of a triple spiral for greater raking capacity with decreased pool agitation. In turn the greater capacity for sand removal creates a larger effective settling area. Both sand and overflow capacity equal that of the next larger size machine of other makes.
- **Modern design** of the WEMCO S-H Classifier gives superior operating results. The main shaft has a diameter up to 40% greater than other spiral classifiers. Flight arms are shorter and stronger, bearings are antifriction and fully protected, and modern hydraulic lifting action is provided for the spiral. Because the design is right, WEMCO S-H Classifiers do more work yet cost you less to run.

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SALT · SILLIMANITE · SCHEELITE · SPODUMENE · VERMICULITE · WOLFRAMITE · AND SIMILAR MINERALS
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Offered by Cyanamid

If you mine or contemplate mining any of the above non-metallic or metallic oxide minerals, these simple facts are important to you:

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2. Grade as well as tonnage will be important for defense-order needs.
3. Quickly, at low capital-cost, many properties can increase output; cut costs by less-selective mining; work deposits now considered to be sub-marginal; and ship higher-grade end-products by adding Processes and Reagents offered by Cyanamid.
4. A very considerable background of test results, design data and operating experience now exists on a long list of non-metallics to assure predictable performance in minimum time at lowest cost.
5. It is not one day too early to find out what Cyanamid can do to help you operate more efficiently into the future.

AMERICAN Cyanamid COMPANY

WHAT CYANAMID OFFERS YOU

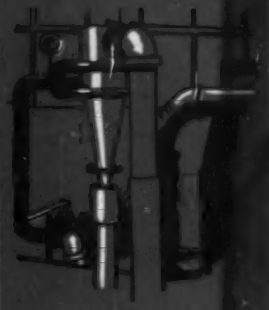
Cyanamid offers the two most efficient Separation Processes by Gravity Difference (Heavy-Media Separation and the Dutch State Mines Cyclone Separator) as well as a group of effective Specialized Reagents and Processes for Non-Metallic Froth Flotation. Alone or in combination, these Processes and Reagents are beneficiating thousands of tons per day in plants as small as 6 tons per hour and as large as 20,000 tons per day.

Cyanamid also offers, after preliminary discussion of your problem without cost or obligation, to run tests on your material in the Cyanamid Mineral Dressing Laboratory; to develop economic beneficiation flow schemes; to suggest proper reagent combinations; to cooperate with engineers of your choice in the design and construction of plants and to assist in tuning up the installation for most effective results.

WHAT HEAVY-MEDIA SEPARATION DOES

Heavy-Media Separation accurately separates valuable mineral from unwanted deleterious material in sizes down to 30 mesh by virtue of their differences in specific gravity. You set the gravity of the Heavy-Media "pool" at any gravity from 1.25 to 3.40 to get the separation you want. From then on, the Heavy-Media unit maintains that gravity within ± 0.01, automatically recovers and reconditions the medium, and feeds it back to the separating pool. On many minerals, you can mine non-selectively by the most economical method with assurance that the Heavy-Media unit will produce a uniform end-product, regardless of how feed fluctuates in quantity or content of unwanted material.

As Technical and Sales Representatives for Heavy-Media Separation Processes, we do not design, build or lease plants but can put you in touch with experienced engineering construction firms who do including those who can make speedy delivery of pre-fabricated "packaged plants" in capacities up to 300 tons per hour.



THE DUTCH STATE MINES CYCLONE SEPARATOR

This unique separation process is particularly applicable to the low cost separation of ¼" x 65 mesh and finer sizes. Employing a unique application of centrifugal and centripetal forces, the Dutch State Mines Cyclone Separator merits study (a) as a low-cost method of pre-concentrating where the feed contains only a small percentage of high-value minerals, (b) to produce a directly-marketable mineral concentrate from fine material, (c) to treat feeds which are inherently not amenable to jig or table treatment, or cannot be economically concentrated by froth flotation.

CYANAMID FROTH FLOTATION REAGENTS AND PROCESSES

Froth flotation is by far the most widely-used process for the beneficiation of fine material and as the final step in the treatment of feed that has been pre-concentrated by mechanical methods. In many instances, it has no peer and its use is constantly being expanded by the development of improved processes and reagents.

With the world's longest and broadest experience in the development and application of flotation reagents, Cyanamid offers the 800 Series, 700 Series, Oleic and other Fatty Acid Promoters, and Higher Alcohol Frothers, as well as Processes for their effective use. We welcome correspondence on these reagents and will gladly give you the benefit of our extensive experience in non-metallic flotation.

TAKE THIS FIRST STEP NOW

First step to more efficient, profitable operation is to send for the booklets listed below. The coupon is for your convenience.

Mineral Dressing Division
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- ☐ MINERAL DRESSING NOTES #14, a 48-page technical booklet explaining *Heavy-Media Separation Processes*, showing flow schemes, plants and commercial operating results.
- ☐ MINERAL DRESSING NOTES #16D, describing in detail the *Dutch State Mines Cyclone Separator*.
- ☐ MINERAL DRESSING NOTES #15, describing *Cyanamid Flotation Reagents* and their fields of use.

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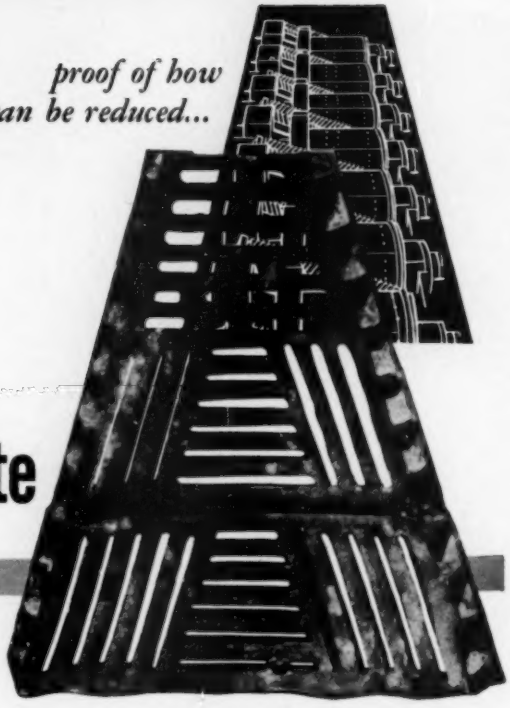
this AMSCO® Grate has milled 193,797 tons



An actual example of how AMSCO Grates last longer, reduce shutdowns and increase milling profits.

Equally Big Savings On Liners, Too!
Recent production figures on Amsco double-wave Liners in a mill grinding copper ore: 667,308 tons ground . . . at a liner cost of about a half-cent per ton! *It will pay you to investigate the long, low-cost service of Amsco Liners!*

Find out more about Amsco Liners and Grates →

Be sure to ask for a copy of Bulletin 449-ML. Describes the characteristics of Amsco ball mill alloys; gives additional facts on dollar-saving installations. Free copy on request.

Here's an actual photograph that proves an important, profit-building point to users of ball mill equipment . . . *the real cost of liners and grates is the actual service cost.*

This Amsco grate has milled 193,797 tons . . . compared with just 113,000 tons for a previously used hardened steel grate which ran under identical conditions. And, during this period of 72% greater tonnage milled, *the Amsco grate required no down-time for repair.* The previously used grate started to crack at 50,000 tons—required many shutdowns for plugging holes.

Because of heavy impact, this particular Amsco Grate was made of austenitic chromium-manganese steel—one of three Amsco alloys developed for specific conditions of impact and/or abrasion. These Amsco liner and grate alloys can result in big savings on milling costs. Amsco Engineers are fully qualified to make alloy recommendations based on your operating conditions—*write today for the name of the Amsco engineer nearest you.*

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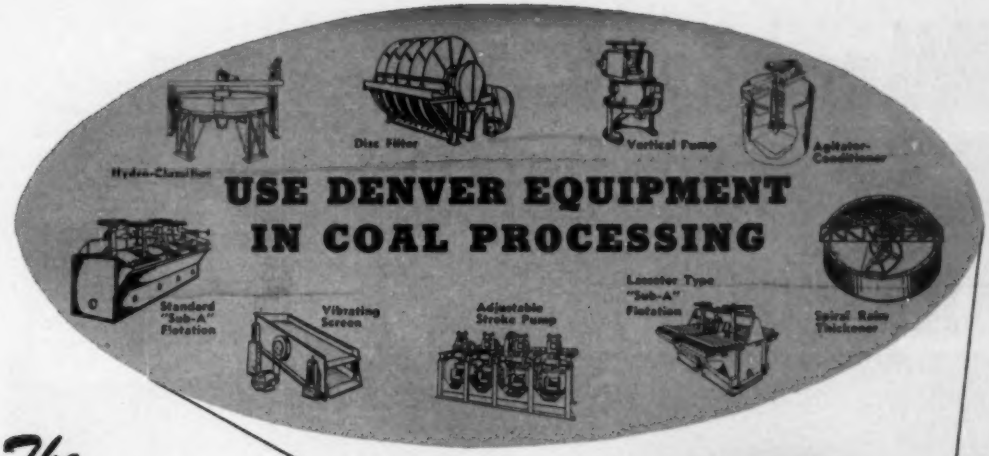

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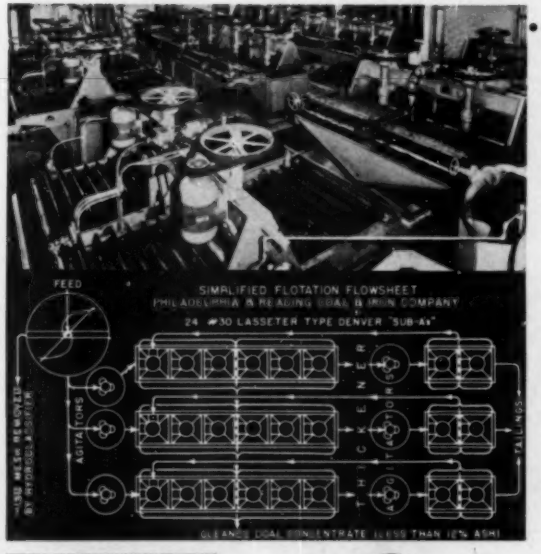
PHILADELPHIA & READING COAL & IRON CO. *Uses*

DENVER "SUB-A" (Lasseter Type) FLOTATION



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Products: Anthracite Coal Fines.

Particle Size: Minus 10 mesh to plus 200 mesh.

Tonnage: 150 TPH initial feed.

Flotation Cells: 24 No. 30 (Lasseter type) Denver "Sub-A" Cells.

Flotation Feed: Ninety tons per hour (minus 150 mesh removed from original feed).

Flotation Concentrate: Sixty tons per hour. (One ton per minute.)

Ash Content: Less than 12 per cent.

Reagent Cost: Less than 15 cents per ton feed.

Hear this Story AT A. I. M. E.

Read this Story IN DECO TREFOIL

This complete story will be told at the February 1951 A.I.M.E. meeting in St. Louis by Mr. H. R. Hagen of the Philadelphia and Reading Coal and Iron Company . . . and will be printed with details and pictures soon in Deco Trefoil.

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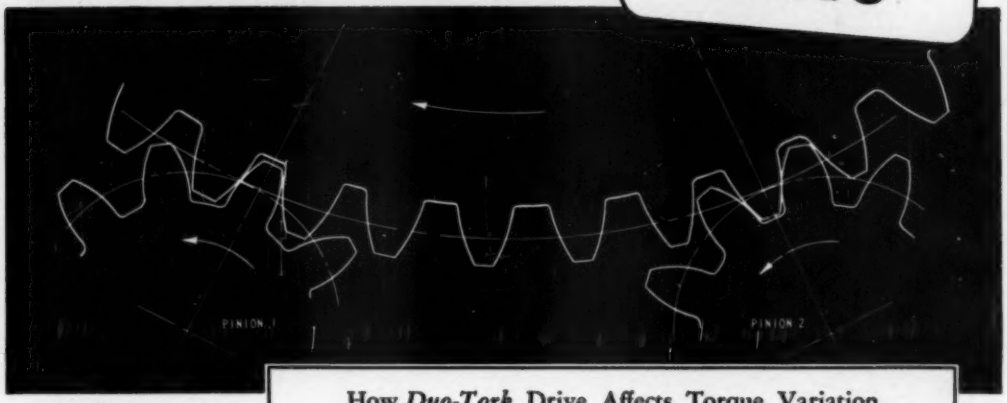
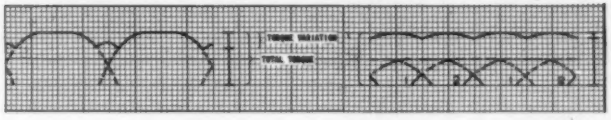
DUO-TORK (STAGGERED PINION) **Drive**



Duo-Tork drive eliminates "hard" gear tooth impulses. Pinion tooth in contact on pinion No. 1 is on centerline between gear tooth centers. Same tooth on pinion No. 2 is staggered — one-half tooth pitch past centerline.

How *Duo-Tork* Drive Affects Torque Variation



Single Drive with New A-C Gearing. *Duo-Tork* Drive with New A-C Gearing.

NEW *DUO-TORK* drive is a staggered pinion dual drive for large rotary kilns developed by Allis-Chalmers to give you twice as many gear tooth contacts per kiln revolution as a single drive (see above). The result is a smooth drive that protects the kiln, bearings, gears, reducer, shafting, and motor from destructive vibration.

Pinions are staggered so that they are one-half tooth pitch out of step. Vibration caused by gear tooth contact is practically eliminated. Each tooth impulse has only half the force of a comparable single drive. And *Duo-Tork* drive assures continuous production because kiln can be operated at reduced capacity using only half the drive.

Gear tooth shape has been improved, too. *Duo-Tork* drive utilizes the new 20° involute spur gear with long addendum pinion and short addendum gear tooth. The pinion tooth *rolls* evenly on gear tooth — *smooth, even* distribution of force from pinion to gear!

Other advantages of *Duo-Tork* drive:

- **Eliminates need for large special reducers and flexible couplings.**
- **Lower tooth pressures mean better gear lubrication, with no scoring or "wiping" of gear teeth.**
- **Maximum economy. *Duo-Tork* drive is less costly than single drive of over 125 hp. And, because wear is reduced, gearing lasts longer.**

For more facts, contact the A-C representative in your area or write Allis-Chalmers, Milwaukee 1, Wis. A-3280

ALLIS-CHALMERS

Duo-Tork and Texrope are Allis-Chalmers trademarks.

Sales Offices in Principal Cities in the U. S. A. Distributors Throughout the World.

Motors

Controls

Texrope Drives

Vibrating Screens

Jaw Crushers

Kilns, Coolers, Dryers

DORRCO DOINGS IN 1950

World conditions, as I write, are grim enough. They call for the response and concentration of purpose we know we would automatically get in an all-out war—but short of that, they do not come easily. The present situation is a tougher test for all of us, but one no less critical. The least profitable way to spend our attention and emotions now is in the search for scapegoats. If we were honest with ourselves, many of us would probably feel that our own ways of thinking or inaction had in some degree contributed to it. Let us apply this to the present and the future. They have enough to occupy us.

* * *

CLASSIFICATION—Our HX Classifier continues to take over the heavy-duty applications formerly handled by the FX. In this country nine duplex HX's are going in at an existing copper concentrator, while eight Quadruplexes and Quadruplex Bowls will be used in a 100 per cent expansion at another property.

The Dorrco Hydroscillator, and its work at Tennessee Copper, has been written about in several A.I.M.E. papers this year. This unit has reduced power consumption for fine grinding by yielding a definitely cleaner sand product. Its ability to produce clean, slime-free sand with only a small fraction of the water used in conventional hydraulic classifiers opens up promising new fields of application, such as the desliming of phosphate sands and the sand fractions of other non-metallic minerals.

JIGS AND CONES—The Dorrco Pan-American Jig continues to find favor in various types of dredge operations, and is now being applied to the beneficiation of iron ore in Minnesota and the concentration of tin ore in Malaya. The DorrClone (Dutch State Mines Cyclone) is entering new fields, notably the degritting of milk-of-lime and clay slurries, the desliming of mill tailings for use as mine back-fill, and the desliming of phosphate rock, sands, fine coal, and iron ore. Recently developed automatic control of discharge density has greatly improved operation under fluctuating feeds.

KRAFT MILL RECAUSTICIZING—1950 has been an active year in this field, with considerable replacement business and some expansion. Two-stage lime slaking, our new development, promises to improve control and assure a white digestion liquor of uniform strength, regardless of fluctuations in the burned lime feed.

SANITATION—The new Dorrco Aerator-Clarifier, a compact unit combining the functions of pre-aeration, flocculation and sedimentation in a single tank, increases the removals of suspended solids and B.O.D. over sedimentation alone.

Large-scale Dorr Multdigestion is used in recent installations at the Los Angeles Hyperion Plant for 245 million gallons of raw sewage per day, and Oklahoma City's Southside Plant, handling 25 million gallons.

Miami, Florida, is installing four 69 ft. dia. Dorrco Hydro-Treators to soften up to 52 million gallons of water a day at their new plant.

CANE SUGAR—There has been great activity this year in cane sugar, particularly in Brazil, where many factories have purchased our new Multifeed Clarifiers and Oliver-Campbell Filters.

ABROAD—Our six associated companies in Europe have been increasingly active and have handled a record volume of business. Three of them celebrated their 25th Anniversary in 1950, although one, Dorr-Oliver, Ltd., started as an agency in 1911. Another one, our seventh, Dorr-Oliver (India) Ltd., started this year.

Projects have included causticizing plants for Portugal and India, another fertilizer plant for Greece, and equipment for base metal production in Italy, Morocco, and the Middle East. India has a Biofiltration Plant operating in Bombay, with others under construction, and water plants for textile production.

Our first completely modern plant for the primary treatment of sewage in South America is under order for Recife, Brazil, to care for 130,000 people. Vacuum filtration and flash drying of sludge, plus the generation of power from sewage gas are to be features new to South American practice.

ION-EXCHANGE—All of the beet sugar factories employing our Ion-Exchange Systems report continued satisfactory operation and increase in the recovery of sugar. Our Continuous Water Softener, based upon ion-exchange principles, has been demonstrated commercially for municipal water supplies, and is also applicable to softening low pressure boiler feed water.

CONSULTING ENGINEERING—The Consulting Engineering Department is serving a broad and expanding field. Highlights this year were a pilot plant for the leaching, roasting and electrolytic treatment of copper ore in Michigan; the modernization of an old gold milling plant in South America, and the handling of a complete chemical fertilizer project in Greece.

FLUOSOLIDS AND FLUODRY—FluoSolids Systems for calcining refractory gold concentrates are being installed at Cripple Creek, Colorado, and one additional System added to the two existing systems at Red Lake, Ontario. Roasting of zinc sulfide concentrates has received much attention during the year, with one test unit being installed and another under design for this country.

The shortage of elemental sulphur, both here and abroad, has emphasized the need for securing more sulphur by roasting the plentiful supplies of iron sulfides—an ideal application for FluoSolids.

FluoDry, a newly developed application of the FluoSolids technique to drying and sizing fine material is being tried on 100 mesh dolomite to both dry and size at that mesh at a rate of 30 tons per hour.

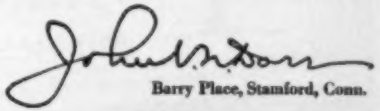
* * *

The beginning of the year found us completing our general office move to Stamford, Connecticut, from New York, and making the required personal and corporate adjustments. The consensus of both staff and observers is that it has been a forward step which has added to our ability to serve.

Some time ago I came into the office and found an associate tearing his hair over something gone wrong. I had just read a review of Dr. Edward Hume's book "Doctors East and West" which told how, when his life's work at "Yale in China" seemed crumbling and his life in danger, he remained calm and full of faith. I told him the story and said then, "I, also, will not worry . . ."

Today, I think again that "Faith" and a serene belief in the final triumph of "Good" is our salvation.

To all friends "World-Wide" and our staff and associates comes our belief that the New Year will bring blessings.



Barry Place, Stamford, Conn.

DORRCO

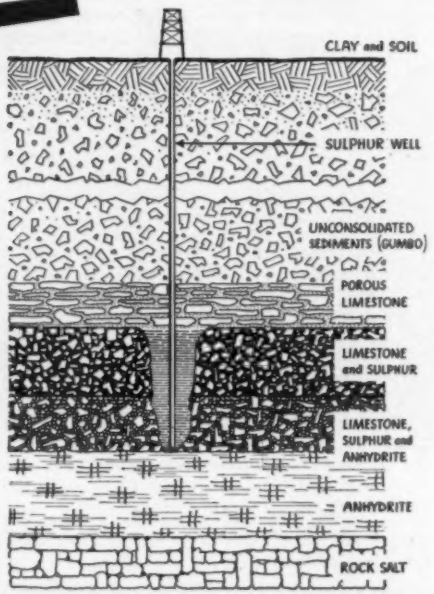
SULPHUR

*Interesting Facts Concerning This Basic Raw Material from the Gulf Coast Region

*DEPOSITS . . .

Practically all of the elemental sulphur used in this country comes from mines in Louisiana and Texas.

There, the sulphur deposits occur in the cap rock overlying certain salt domes. The sulphur is mined at depths of 300 to 2,000 feet below the surface. It is melted in place by pumping into the deposit water heated under pressure to a temperature above the melting point of sulphur. The melted sulphur flows away from the limestone and is pumped to the surface where it is allowed to solidify in vats. By such means sulphur nearly 100% pure is produced.



Loading operations at our Newgulf, Texas' mine

TEXAS GULF SULPHUR CO. INC.

75 East 45th St. New York 17, N. Y.

Mines: Newgulf and Moss Bluff, Texas

Position of the control zone in a Traylor TY Reduction Crusher accounts for its amazing production efficiency

TRAYLOR CURVED CRUSHING SURFACES check lifting and churning of material by applying power as a direct crushing force to obtain a more uniform product on less power-per-ton produced.

TRAYLOR BELL HEAD and CURVED CONCAVES place the crushing zone of smallest volume here, well above the opening where packing and choking commonly occur. Capacities of all succeeding zones are progressively greater . . . *free discharge is assured.*

Observation of a large number of installations has disclosed that Traylor self-tightening bell head and curved concaves enable operators to consistently produce large tonnages of small, uniform product with low percentages of oversize and waste fines. More efficient application of crushing force reduces wear-per-ton and power-per-ton factors. A Traylor TY Reduction Crusher introduces unsurpassed efficiency to any secondary crushing operation.

SEND FOR THIS FREE NEW BULLETIN. *Contains complete details on Traylor TY capacities and sizes. Mail coupon today.*

TRAYLOR ENGINEERING & MANUFACTURING CO.
315 MILL ST., ALLENTOWN, PA.

I want to see how a Traylor TY will cut my reduction costs.

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Company_____

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Traylor

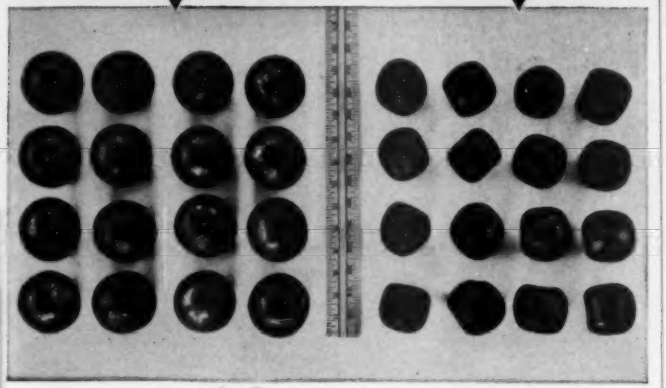
Rotary Kilns, Coolers and Dryers · Grinding Mills
Jaw, Reduction and Gyratory Crushers · Crushing Rolls

A "TRAYLOR" LEADS TO GREATER PROFITS

SHEFFIELD
MOLY-COP
COPPER-MOLYBDENUM ALLOY

VS.

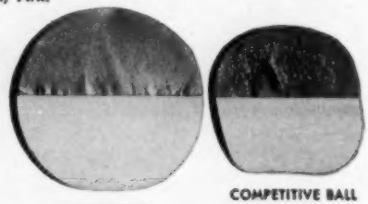
COMPETITIVE FORGED BALLS



THERE *IS* A DIFFERENCE IN FORGED STEEL BALLS

Again, the longer wearing qualities of Sheffield Moly-Cop balls have been demonstrated. This time in a test grinding barite ore at Magnet Cove Barium Corp., Malvern, Ark.

An equal number of Moly-Cop and competitive forged steel balls were charged into the same mill at the same time and were recovered after 4604 operating hours. All were originally 3½ inch nominal diameter and marked for identification.



MOLY-COP COMPETITIVE BALL

The recovered test balls are shown in the top photograph. Clearly evident is the difference in rate of wear. The *competitive forged balls wore 38% faster*, based on average diameter loss. Note also the pronounced difference in retention of spherical shape.

Typical fractures of the two types of test balls are shown in the lower photograph. Note the fine, hard, martensitic grain structure of the Moly-Cop ball.

Carbon and Alloy Steel Ingots, Blooms, Billets, Plates, Sheets, Hot Rolled Bars, Steel Joists, Structural Shapes, Reinforcing Bars, Welded Wire Mesh, Wire Products, Wire Rods, Fence, Spring Wire, Nails, Rivets, Grinding Media, Forgings, Track Spikes, Bolt and Nut Products

The economy of Moly-Cop balls has been borne out in reports from all over the world. A comparative test in your own mills will demonstrate just how much more economical are Moly-Cop balls in your grinding operations.

SHEFFIELD STEEL CORPORATION
HOUSTON KANSAS CITY TULSA

Export Representative:
ARMCO INTERNATIONAL CORPORATION
MIDDLETOWN, OHIO

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☐ Delivery Promise
☐ Sample of _____
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Signed: _____

(TITLE) _____

MIE-2

THE FIRST REAL PIPE THAT IS PLASTIC

ONLY CARLON plastic pipe is **guaranteed** against rot, rust, and electrolytic corrosion. This durable, lightweight pipe has a trouble-free service life many times longer than ordinary pipe because it is unaffected by sulphurous waters, alkalis, metallic salts, and other corrosive wastes.

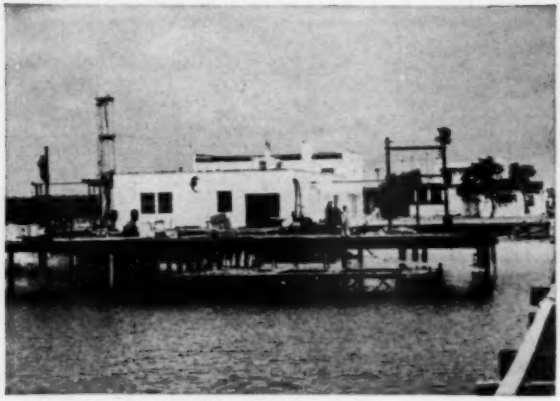
Both flexible and rigid types of CARLON are available to meet the diversified requirements of surface and subsurface mining operations. Flexible pipe is furnished in long lengths and will conform to irregular surface contours or ditch lines. In addition, it requires fewer fittings per installation than any other pipe. Rigid CARLON is shipped in 20-foot lengths which can be made-up rapidly with either cemented-sleeve or threaded connections, and it can be threaded with standard pipe tools to meet individual requirements. Extensive research and field testing have proven conclusively that CARLON plastic pipe is superior to other mine pipes, and that it eliminates costly maintenance and replacement programs.

Remember . . . when you pipe for the future, specify **ONLY CARLON.**

CARLON PRODUCTS CORPORATION

IN CANADA: MICRO PLASTICS, LTD., ACTON, ONTARIO

10348 **MEECH AVENUE • CLEVELAND 5, OHIO**



View of Harbor Island Laboratory and Testing Station.

New testing station provides expanded facilities for corrosion studies

During the past 15 years, the Atlantic Ocean at Kure Beach served as a giant test tube for studying attacks of sea water and salt air upon more than 35,000 specimens, including virtually all types of metals and alloys.

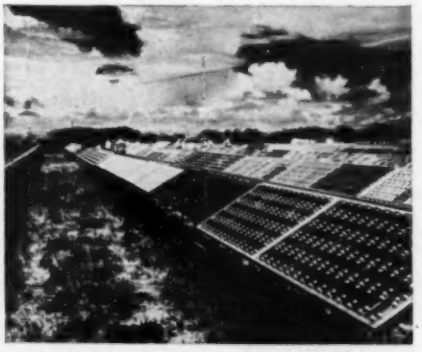
Storm damage to the basin, in which the underwater tests were conducted, compelled establishment of a new and protected testing station. Accordingly, some 15 miles north, on Harbor Island, the new Inco Marine Laboratory was built to provide expanded facilities and an even better "Ocean Test Tube."

This new Harbor Island station, along with the atmospheric test racks retained on the shore of Kure Beach, now widen the scope of cooperative enterprise for fighting industry's common enemy — *corrosion.*

The vast amount of valuable data accumulated over the years will continue to be made available to all industry, as well as to government agencies for whom and with whose cooperation much of the research has been undertaken. You are invited to consult us on your corrosion problems.

Lowering piling test specimens into place. Sea water is something more than a mixture of chemicals; its corrosive action over an extended period can be studied properly only by exposure of specimens to attack under natural conditions.

Running water troughs. For studying the action of sea water flowing at moderate velocities, specimens are immersed in the troughs, shown above. The total length of trough used for this purpose now amounts to about 600 feet.



Atmospheric and spray test lot. Shown above is part of the atmospheric test lot at Kure Beach in which over 20,000 specimens have been exposed, some for over nine years. The racks face south, and the specimens, supported on porcelain insulators, are all set at a slope of 30 degrees.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N.Y.

* Phosphate from the Maiden Rock deposits in the Missouri River Basin, Mont., are to be developed by the Victor Chemical Works of Chicago. A $5 million plant for processing the rock into elemental phosphorus is to be constructed in the vicinity of Butte. The plant will receive power from the Bonneville Power Administration.

* Tests are being made to determine whether iron pellets from taconite concentrates will boost blast furnace and open hearth output at the Campbell Works of the Youngstown Sheet & Tube Co. About 35,000 tons of iron pellets have been shipped from Minnesota for this purpose.

* Iron ore stocks are periously low in the face of critical demand for iron and steel for defense orders. Additional ore carriers are being built but will not be completed in time to increase 1951 shipments. Large tonnages of iron ore are being moved by rail to eastern furnaces for the first time in history.

* Slab zinc production in 1950, amounting to 910,375 tons, was the highest since 1943 in spite of lost output from strikes and shutdowns, according to Ernest V. Gent, executive vice-president of American Zinc Institute. Smelter deliveries were up 25 pct over 1949 as smelter stocks were heavily drawn upon to meet the shortage of the metal which marked the year. Domestic mine production is expected to be 4 pct up over 1949 when final statistics are received.

* High grade iron ore shipments from Iron Mines Co., Venezuela, subsidiary of Bethlehem Steel Corp., are expected shortly. Initially they will be at the rate of 2 million tons per year.

* Profits of domestic gold producers rose between 10 and 25 pct in 1950, according to Standard & Poor estimates. Homestake showed the greatest increase by attainment of capacity operations and mining above normal grade ore. U. S. mine output, including by-production, came to about 2,400,000 oz, up 23 pct over 1949.

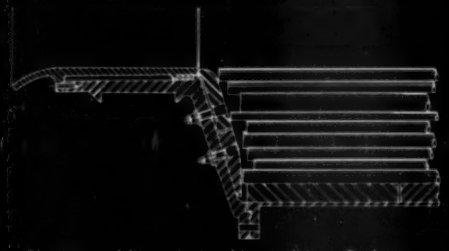
* A severe earthquake in Asia in August 1950 caused the water in some wells in the United States to fluctuate. Automatic water-stage recorders on wells penetrating the Edwards limestone in San Antonio recorded the quake much as seismographs might do.

* Defense Minerals Administration is reported to be favorably considering the White Pine copper mine project in Michigan but the amount of production has not been decided. Estimate of the DMA loan required for production of 150 million lb of copper per year is $100 million which is 1/6 of DMA funds.

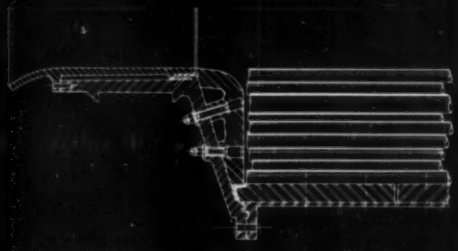
Allis-Chalmers Builds Rod Mills with Straight *INSTEAD OF SLOPING* End Liners

HERE'S WHY...

- Less Rod Overlap
- Less Wasted Grinding Area
- Less Gouging of End Liners by Protruding Rod Ends
- Better Grinding Efficiency . . . Less hp per ton
- Minimum Tramp Oversize in Product



Sloping end liners invite this condition. Rods overlap, causing wasted grinding area at rod ends and excessive wear on end liners.



Vertical end liners keep rods even in mill. Wear on end liner is greatly reduced. All of rod length is utilized for useful grinding.

STRAIGHT END LINERS mean better grinding performance all around . . . with less costly maintenance. That's why vertical end liners are standard on Allis-Chalmers rod mills.

It adds up to this—close control of product top size . . . and less hp required to grind more product. All available rod length is utilized. No wasted power caused by rod overlap. The actual gain in grinding efficiency with vertical end liners may be as high as 2 percent!

Allis-Chalmers is the *only manufacturer* building large rod mills with vertical end liners. Other reasons why it pays to specify Allis-Chalmers for grinding mills:

- There's no pocket between end liner and head at trunnion end to fill with pulp and form a race. This space is filled with cement before end liner is installed.
- Three packing rings seal space between trunnion liner and trunnion.
- Trunnion bearings on larger size mills are equipped with an individual high pressure lubricating pump to "float" the mill for starting. No destructive bearing wear caused by high starting torque.

There is an Allis-Chalmers engineer-consultant in your area who can point out other advantages of A-C grinding mills . . . and help you work out your grinding problems. Call him, or write Allis-Chalmers, Milwaukee 1, Wis.

Allis-Chalmers builds overflow, center and end peripheral discharge rod mills; ball, pebble and preliminator mills; multi-compartment Compeb and Ballpeb mills.

Texrope, Compeb and Ballpeb are Allis-Chalmers trademarks.

A-3241

ALLIS-CHALMERS

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Motors | Controls | Texrope Drives | Vibrating Screens | Jaw Crushers | Kilns, Coolers, Dryers

Time Now For Thinking

IN these turbulous times a natural restiveness is created among the younger men of the mining profession. Many of them are veterans of World War II and the question is raised in their minds as to whether or not to go back into military service. There is time to think about this question now and it is advisable to do so in order that snap decisions may be avoided if war is declared.

In the five years since the armistice these engineer-veterans have had time to develop into experienced engineers. The nation is facing shortages of metal supplies even under present circumstances of partial mobilization. Trained engineers are needed to alleviate this situation. Youthful vigor is necessary to provide the field working force to develop the many mining projects which the government, in cooperation with the nation's leading mining companies, has in the planning stage.

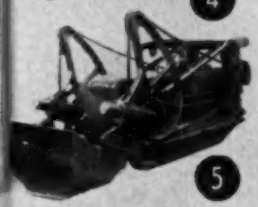
To a certain degree there will be competition from the armed service for the engineers under 40 years of age. Pay, adventure, and prestige attached to military service is strong inducement especially if the working conditions for engineers are not satisfactory. It is the duty of the mining companies to keep salaries commensurate with responsibility of engineering employees. In addition these engineers must be pushed to the limit of their capabilities so that they may have the satisfaction of measuring up to the job. With a shortage of engineering personnel throughout the nation, companies that are temporarily well staffed must not let eager hands lie idle. In times of crisis everyone wishes to be doing his utmost for the common cause.

The engineer's obligation is to recognize that his post is in the industry for which he is trained, especially since that industry is hard pressed to meet the demands of a nation girded for war. The draft board is the agency designated to make decisions as to whom should be called for military service. It is in possession of the facts on man power requirements in its area of jurisdiction and should be relied upon for this purpose.

As long as enlistments are accepted regardless of the industry from which the volunteers come, the wisdom of the young men is industry's only protection against being stripped of technically trained men. The time for the industry and the younger engineers to think about these things is now so that sound judgment will prevail during the emotional period of crisis.

LOADING ROCK

FASTER . . . CHEAPER



Tunnel drivers used to estimate 2½ to 3 feet of tunnel width for a man. This rapid calculation told Mr. Tunnel Driver how many men could work with shovels in the face at one time. A good worker could load 1½ cubic yards per hour.

Modern Tunnel drivers estimate the size of their heading for the largest Eimco RockerShovel they can use. They know the capacity of RockerShovels. The smallest (Model 12B) will load 1 cubic yard or more per minute (as much as 45 men).

RockerShovels give the man a longer, stronger arm. He does more work yet he goes home without physical strain.

Eimco tunnel loading equipment is fast, economical and dependable. Air, Electric, Gasoline and Diesel powered models are available. Check with Eimco before buying loading equipment .

1. Model 12B, smallest RockerShovel. Loads 1 to 2 tons per minute. 5'6" headroom required. Bulletin L1010.
2. Model 21, medium size tunnels. Loads 2 to 3 tons per minute. Air or electric power. Bulletin L1011.
3. Model 40, for high speed loading. 3 to 5 tons per minute. Track gauge from 24" to standard railroad. Bulletin L1009.
4. Model 15, transport model. A self-loading truck. Gasoline or electric power. Bulletin L1013.
5. The 102 RockerShovel crawler mounted. 3 to 5 yards per minute. Bulletin L1023.
6. The 104 RockerShovel crawler mounted. 6 to 8 yards per minute. Bulletin L1019.
7. Model 17. The shaft mucker for large shafts. Write for information.

EIMCO

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AGENTS IN ALL PRINCIPAL CITIES THROUGHOUT THE WORLD

Washington By-line

FOLLOWING the declaration of a national emergency by the President on Dec. 16, 1950 the Office of Defense Mobilization was established with Charles Wilson as director. It has been obvious since the entry of Red China into the Korean War that the previous defense setup was not adequate for accelerated mobilization.

The new defense organization now includes a Defense Production Administration which has been delegated all the important powers previously granted various agencies of the Government by Executive Order 10161 (pursuant to the Defense Production Act). Specifically, the DPA has powers over the functions provided for in sections 302 and 303 of the Defense Production Act relating to production, capacity, and supply. Although this means the DPA will retain ultimate authority over the certification of loans for the exploration, development, and production of strategic and critical minerals, it is expected that the recommendations of the Defense Minerals Administration will carry considerable weight in this regard. It is also expected that priorities and allocations powers over nonferrous metals and ferrous metals (up to the blast furnace stage) previously delegated to the Secretary of the Interior by NPA will be re-delegated to said Secretary by the Defense Production Administration. It is further anticipated that the Defense Minerals Administration will be once again delegated the function of determining the eligibility of defense facilities (including construction on mineral properties) for accelerated tax amortization even though the DPA will have final say in the matter.

• Representatives of the copper, lead, and zinc industries met in Washington in early January with officials of the Economic Stabilization Agency. All agreed that since prices for these three metals have been stable in recent months there was no need for price ceilings now. The ESA asked producers to give notice when they felt it necessary to raise prices.

The ESA issued a warning on Dec. 19, 1950 that prices of certain basic materials which were increased between June 24 and Dec. 1 are subject to reduction, particularly in cases where it is necessary to maintain Dec. 1 price levels at later stages in the manufacturing process. The price of lead, more than prices of copper and zinc may be subject to reduction since lead has risen six cents a pound in the past six months.

• The Government is moving closer to a controlled materials scheme with the appointment of Walter C. Skuce as director of NPA's production controls staff. Mr. Skuce was the head of the Controlled Materials Plan under the War Production Board during World War II. Mr. Skuce will supposedly take charge of NPA planning for a similar allocations setup in this defense period.

Another hint that the Government is moving in this direction can be seen in the recent end-use control of about 250 items containing copper and copper-base alloys.

• President Truman and Prime Minister Atlee stated in a joint communique recently that they "recognized the necessity of international action to assure that basic raw materials are distributed equitably in accordance with defense and essential civilian needs." They stated further that consideration of this matter would continue. It was not so stated but nevertheless understood by observers that the metals which were probably discussed in this regard are aluminum, copper, and zinc.

The British have been complaining for some time about a raw materials shortage. They ascribe the situation in large measure to United States stockpiling of scarce materials. They believe that American stockpile policy should be modified with regard to certain materials if Britain and Western Europe are to obtain these needed for rearmament.

• Complaints are widespread over the unsuitability of Government application for loan forms which are currently available to those desiring Federal assistance for the exploration, development and production of strategic and critical minerals. One objection is that the form provokes unnecessary mental gymnastics on the part of the applicant. It is hoped that a form more suitable to the peculiarities of the mining process will soon become available.

Another complaint of the form arises as a result of a provision stated therein which binds the applicant to "reimburse any agency of the United States government upon demand for any expenses incurred in connection with or arising out of this application or any loan made pursuant hereto." It is obvious that many a small miner justifiably cannot approve this "blank check" provision.

• On Dec. 27 last the NPA issued a list of scarce materials, including metals and minerals, which cannot be accumulated in excess of the reasonable demands of business or for the purpose of resale at prices above prevailing market prices. Various categories of 23 metals and minerals are mentioned including the much-publicized items of copper, zinc, aluminum, columbium, cobalt, manganese, tungsten, nickel, and tin.

• The excess profits tax is now a reality. Provisions pertaining to mining include the exemption of one-third of the net income from mines (1) in production subsequent to June 25, 1950; (2) in operation prior to June 25, 1950 but not in operation on that date; (3) those properties operating at a loss during the base period (1946 to 1949). The exemption in the World War II act for strategic minerals has been continued with certain additions made to the list. There is also a provision excluding from taxable income Government grants and loans made for the purposes of exploration, development and production of strategic and critical metals and minerals. Provision is also made for the exemption of one half of the unit net income from excess output from the tax.

• The Commerce Dept. has set an export quota for sulphur of 200,000 long tons of crude sulphur and 7500 tons of refined sulphur for the first quarter of 1951. This represents about a 28 pct cut in sulphur exports from previous shipments but was necessary to alleviate the tight supply situation.

ANNUAL REVIEW

NONFERROUS METALS

Emergency Demands Force Rising Prices and Increased Mine Production

BY SIMON D. STRAUSS

PRODUCTION and consumption of nonferrous metals in the United States during 1950 were at peak levels for the postwar period, as is shown in Tables I, II, and III. The trend of production was upward through most of the year. At the year end, with the possible exception of the Tri-State zinc-lead district, the large mining operations in the country were running at capacity. The absence of serious labor interruptions during the year was an important contributing factor in the increased output of metals, since in each of the previous postwar years there had been a number of major strikes which affected production adversely.

It is perhaps natural for those outside the industry to consider that the current shortages of metals are the result of the war boom arising from the Communist aggression in Korea in late June. But actually the shortages had already developed in copper and zinc before the Communists struck and the basic situation in lead was changing—although marketwise the correction of the surplus conditions which prevailed through most of 1949 and early 1950 was not yet fully apparent at the end of June.

The year 1949 had become the poorest in the postwar period for the nonferrous metal producers. Demand from consuming industries dropped sharply during the spring of the year and with the drop in demand prices were severely depressed. By midsummer of 1949, production had been severely curtailed in copper and zinc. Many of the small lead producers also closed down but over-all mine production of lead was somewhat higher than in 1948 (in 1948 the largest mine operator had had a prolonged strike).

Consequently when early 1950 saw an unprecedented civilian demand for housing, automobiles, electrical appliances and other metal-consuming civilian goods, the stocks of unsold metal which the producers had accumulated in 1949 began to melt rapidly. By June these stocks were at minimum working levels in both copper and zinc. Lead stocks were still above normal and the prospect that the government, which was an avid buyer of both copper and zinc for the stockpile, would not add to its lead stockpile seemed to put that metal in definitely inferior position.

As stocks dwindled, prices rose and mine production rose correspondingly to the peak of available capacity. It was quite apparent, therefore, at mid-year that if the changed military and political situation required a major armament effort, the metals for that effort could be made available in only one of two ways. Either civilian consumption of metals would have to be curtailed below the high rate of early 1950 or the government would have to reduce the rate at which it was accumulating stockpiles—perhaps eliminate stockpiling entirely.

Although these alternatives seemed clear at the time, the government officials charged with economic and military policies were slow to decide. It was only at the very end of 1950 that serious efforts were made to curtail civilian use of metals through regulations issued by the National Production Authority. In the meanwhile the metal producers had been subjected to tremendous economic pressure. Consumers, anticipating regulations that seemed certain to come but that had not yet been issued, frantically endeavored to buy increased supplies. Although the newly-mined domestic mine production was marketed as rapidly as it was available at the prices published in the responsible trade press and although the bulk of the imported supplies also were offered on the same basis, an outside market rapidly developed at substantial premiums over the so-called producers' prices.

This outside market was fed principally from two sources— a small volume of foreign metal coming from sources which do not usually sell in the United States and a larger volume of metal derived from the treatment of scrap materials. Owners of scrap were unwilling to sell on the basis of the producers' prices and succeeded in finding customers among the consumers who would pay higher prices. The scrap thus bought was converted into metal on a toll basis.

Copper

The price history of copper during 1950 provides an illustration. On Jan. 1 copper was selling at 18½c per lb, delivered Connecticut Valley, and by the end of May, prior to Korea, had moved up to 22½c per lb, at which point it was still 1c below the 1948 high of 23½c per lb. On July 1 the picture was complicated by the reimposition of the 2c per lb excise tax on all copper imports (except scrap) as a result of the failure of Congress to continue the suspension of the tax, which under previous legislation had been suspended only through June 30, 1950.

In mid-July one domestic producer increased his price to 24½c per lb, thereby giving full effect to the excise tax. Foreign sellers found that their

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foreign customers were willing to pay the same price and consequently they also advanced their price to 24½c, with the understanding that United States consumers would have to absorb the tax. By September all sellers were on the 24½c basis. Consumers were paying the excise tax on all imported supplies so that in effect (since about one third of primary copper supplies came from foreign sources) the average cost of copper to them was between 25¼ and 25½c per lb. Because the proportion of foreign copper purchased varies among the different consumers, in certain cases this average was doubtless substantially exceeded.

No further changes were made during the year in the producers' price. However, on the outside market, to which reference has already been made, prices in excess of 40c per lb were undoubtedly paid and a fairly substantial business was done at levels of around 32 to 35c per lb. During the last quarter of the year the scrap market generally was at these levels, with the consequence that primary refineries were unable to buy scrap at all. What scrap they processed was handled by them entirely on a conversion basis.

The only major new copper plant to begin operations in 1950 was the new 12,000-ton refinery of the Kennecott Copper Co. at Garfield, Utah, which will handle blister from the Garfield smelter of American Smelting & Refining Co. (the latter plant added a new anode casting unit to supply the refinery.)

As the year ended the Defense Minerals Administration was studying projects calling for major expansion of this country's copper-mining capacity but none of these new projects will be in production in 1951. Included are the San Manuel mine of Magma Copper Co.; the White Pine mine of the Copper Range Co.; the East Bisbee mine of Phelps Dodge Corp.; the Silver Bell mine of American Smelting & Refining Co.; and several others. All of them, so far as is known, will have relatively high costs and will require substantial capital investments. In the aggregate they may expand this country's ability to produce copper by as much as 150,000 tons a year as against a present mining capacity of 950,000 to 1 million tons a year. However, it will probably be 1954 or later before they are all in full operation.

In the meantime the limits of copper supply are fairly well defined. Domestic mines, working full tilt, may, as already mentioned, produce 1 million tons a year. Scrap handled through the primary refineries may add 150,000 tons a year. Imported supplies of copper—as ores, concentrates, blister, and refined—may provide about 400,000 tons a year, subject to some economic and political uncertainties.

Price controls in the United States—whether voluntary through restraint on the part of producers or compulsory through government regulations—can mean that foreign consumers will bid prices which will divert a portion of the supplies normally coming to the United States. One way to combat this would be international allocation of raw materials. During World War II the Combined Raw Materials Board did a job of this kind rather effectively, but it was dealing then with a world that was under the naval control of Great Britain and the United States; Western Europe was not then in a position to compete for raw materials. Today the situation is vastly more complex. In any agreement on copper the conflicting interests of the following countries (either as producers or consumers) would have to be reconciled: United States, Chile, Canada, Belgian Congo and Belgium, Rhodesia, Peru, Mexico, Yugoslavia, United Kingdom, France, Germany, Netherlands, Scandinavia, Switzerland, Italy, India and Japan. It will not be a simple task. The inability to resolve the tin problem through international conferences held over a period of the last four years indicates that an early agreement will be difficult. In the meanwhile, the tendency may be for the United States to get less rather than more imported copper—particularly since some of the principal producing countries are resentful over the reimposition of the 2c excise tax.

Zinc

The rise of the zinc industry during 1950 from pauper to prince was more rapid and more surprising than that of copper. At the end of 1949 the price of zinc was at a level—9⅞c per lb—which was tending to still further reduce mine production. The Central district in New Mexico was almost entirely closed down and the Tri-State district was decidedly in the doldrums. Strikes in the steel industry had cut into demand.

Beginning in February a remarkable metamorphosis developed, undoubtedly beginning with the evidence of an insatiable consumer demand for automobiles (there was more zinc used per car in the 1950 models than copper and lead combined) and then stimulated by the housing boom that required ever-increasing tonnages of galvanized products. By April the price was up sharply, stocks were reduced, and preparations were being made to reopen many of the closed mines.

At this juncture the government suddenly reversed its stand on zinc for stockpiles. In June of 1949 zinc producers had been advised that there would be no purchases of zinc for stockpile during the 1949-1950 fiscal year. It was a widely known fact then that the government still held large accumulations of zinc, both as metal and as concentrate, originally acquired during World War II. The decision therefore to stop buying caused disappointment but did not cause surprise.

In April 1950, however, the government decided to resume buying of zinc for stockpile and indicated that its demands would be on a very heavy scale (about 15 to 20 pct of available supplies). The industry pointed out that government buying could not fail to put prices up still further and questioned the wisdom of such extensive purchases in their long-range impact on the industry. These doubts were accentuated by the experience with lead, which was just the reverse of that in zinc. Heavy purchases of lead for the stockpile were made during the 1949-50 fiscal year but then it was decided that none were needed in 1950-51.

This on-again off-again policy can be disastrous to a mining industry which cannot expand production rapidly, because of physical limitations. If the stockpile buys spasmodically, it tends to accentuate the swings in price. If the need no longer exists by the time production has been increased to meet the demand for stockpile, then the added capacity is certain to drive prices below economic levels. These considerations apparently were ignored by those in charge of policy. The government insisted on taking a large share of current zinc production although at the same time turning down long-term offers (over a period of three to four years) which were tied in to expansion of mine production.

The effect of Korea on the zinc market was similar to that on copper. The price had advanced prior to Korea to 15c per lb. Wage increases and the need to stimulate output in the still-lagging Tri-State area resulted in a further jump to 17½c, at which level the market closed the year. Outside zinc, representing metal imported from sources other than Canada or Mexico (the only two countries which regularly supply this market), or metal obtained from conversion of limited quantities of scrap or concentrate on a toll basis, has sold as high as 40c per lb and considerable quantities changed hands at around 25 to 28c per lb.

The foreign market in the last quarter of 1950 ranged between 21 and 24c per lb. Continuance of this premium over the domestic price can have serious repercussions here. As shown in the tabulation, domestic mine production has fallen short of domestic smelter production by 200,000 to 300,000 tons a year. The discrepancy has been largely made up by importation of foreign concentrates (and in lesser measure by drawing on accumulated stocks of concentrate, including government owned.) However, foreign mines will be tempted to ship to foreign rather than U. S. smelters if they can obtain a higher price.

Thus, the supply outlook in zinc is far from clear. Domestic mine production can, and probably will, increase by 10 to 15 pct above the 1950 level. New Jersey Zinc is bringing in a new mine in Pennsylvania; capacity in the Metaline district of Washington is being substantially expanded; Anaconda's output in Montana is increasing; and the Tri-State and Coeur d'Alene districts have the mineral resources and milling plant to support a higher level of operations. On the other hand, the volume of imports, both as concentrate and as metal, is open to some question.

Lead

Lead is considered less important than copper or zinc from a military standpoint, the experience of World War II having been that no serious lead shortage developed. However, gasoline rationing was an important factor in curtailing the wartime use of lead both for batteries and for high-octane gasoline. So long as gasoline is freely available to the civilian public, the demand for lead in these two major uses will continue high. And in other fields of civilian activity lead may be called on to replace copper, aluminum, zinc, and other scarce materials.

It is the recognition of these facts that explains the record consumption of lead in 1950 in spite of the fact that the market was in the doldrums during the first half of the year. Furthermore, part of the weakness in lead was caused by the lack of demand for lead from dollar-area sources in the European market late in 1949 and early in 1950. That lack of demand was due partly to reduced consumption caused by substitution of other metals and partly to increased supplies from non-dollar areas. These supplies were in part nonrecurring reflecting liquidation of scrap accumulations.

With those accumulations now out of the way and with the urge in Europe, as in the United States, to substitute lead for other scarcer materials, it seems probable that the call for lead from the dollar areas such as Canada, Mexico, and Peru to flow to the European market will continue at the accelerated rate evident in the last half of 1950.

Add to this factor the increase in the United States import duty on lead from 1 1/16 to 2⅛c per lb (resulting from abrogation of the Mexican duty) and it is evident that imports of lead in the United States will be substantially less in 1951 than in 1950. In fact, a large part of the 1950 imports represented liquidation of metal accumulated during the dull market of 1949 and thus definitely were of a nonrecurring nature.

Domestic mine production of lead will follow a similar pattern to that of zinc. Lead and zinc come from smaller, but more numerous, deposits than does copper under present economic conditions. The capital investment is smaller and the time required is shorter in which to stimulate production. Nevertheless, bearing in mind the reduced probable level of imports and the liquidation of the accumulated stocks in domestic producers' hands, the volume of lead available to domestic consumers in 1951 is likely to be less than in 1950.

Table I. Copper in the United States in Short Tons

	1948	1949	1950 Estimated
Mine Production[a]	950,088	772,986	935,000
Refinery Production[b]	1,233,697	1,056,463	1,265,000
Imports, Refined Copper	249,124	275,808	315,000
Total Supply, Refined Copper	1,482,821	1,332,271	1,580,000
Exports, Refined Copper	142,598	137,827	135,000
Net Supply, Refined Copper	1,340,223	1,194,454	1,445,000
Deliveries to Fabricators[c]	1,344,445	1,031,595	1,365,000

[a] Mine Production from domestic mines only.
[b] Refinery Production includes domestic mine output; secondary materials treated at primary smelters and refineries; imported ores and concentrates smelted in the United States, and imported blister refined here.
[c] As reported by the Copper Institute. Does not include deliveries to the stockpile.

Table II. Lead in the United States in Short Tons

	1948	1949	1950 Estimated
Mine Production[a]	390,476	404,032	430,000
Refinery Production[b]	511,356	542,676	574,000
Imports, Refined Lead	247,368	275,240	410,000
Total Supply Primary Refined Lead	758,724	817,916	984,000
Deliveries of Primary Lead to Fabricators[c]	750,000	579,000	875,000

[a] Mine production from domestic mines only.
[b] Refinery production includes domestic mine output; secondary materials treated at primary smelters and refineries; imported ores and concentrates smelted in the United States; and imported bullion refined here.
[c] As estimated by the American Bureau of Metal Statistics for 1948 and 1949, by the writer for 1950. Does not include deliveries to the stockpile.

Table III. Zinc in the United States in Short Tons

	1948	1949	1950 Estimated
Mine production[a]	629,977	583,882	625,000
Smelter production[b]	850,105	870,113	915,000
Imports, Zinc Metal	93,283	126,924	153,000
Total Supply, Zinc Metal	943,388	997,037	1,068,000
Exports, Zinc Metal	65,757	58,706	65,000
Net Supply, Zinc Metal	877,631	938,331	1,003,000
Deliveries to Consumers[c]	820,000	712,000	950,000

[a] Mine production from domestic mines only.
[b] Smelter production includes most of domestic mine output (a portion is converted directly to zinc oxide); secondary materials treated at primary smelters; and imported concentrates smelted in the U.S.
[c] Estimates by U. S. Bureau of Mines in 1948 and 1949; by writer in 1950. Excludes deliveries to stockpile.

ANNUAL REVIEW

GEOLOGY is Still the Key to Mineral Supplies

Iron ore country of Labrador which is being opened by M. A. Hanna and others.

by Roger H. McConnel

THROUGHOUT the world in 1950 there has been extensive exploration for metals, with emphasis on iron, copper, gold, lead, and zinc.

Among the features most apparent in reviewing exploration and development are the staggering sums required, the over-riding influence of government policies throughout the world, and the need for intensified search.

The conservatively inclined point out the decreasing frequency of major discoveries, and the *per capita* rise in use of metals by increasing world population. The more optimistic claim that to supply the rising demand new discoveries will be made, known deposits will be more efficiently mined and further advances in technology will permit use of lower grade ores. The truth probably lies somewhere between these extremes of opinion, and in the future lies an adventure in teamwork unparalleled in the history of the mining industry.

The period has passed when surface outcrops of significant ore bodies could be found by walking over an area and observing the ground with reasonable care. E. C. Stephens has aptly said that the relatively simple methods of the prospector and the measurement techniques of the mining engineer are reaching a point of diminishing returns. Today geological and geophysical techniques and understanding, capable of pointing out areas containing better-than-average possibilities for ore, are needed to probe through overburden and to narrow the target for expensive underground exploration. Because of the cost and time involved, the rate of discovery is not as rapid as with the older methods.

The careful, sometimes tedious, and sometimes too-little-recognized work of the mine geologist diminishes the danger of overlooking hidden ore. The information which he gives on the geometry and physical character of a deposit aid in improving mining methods and reducing costs.

Teamwork can hardly be overemphasized. The mining geologist is but one member of a team whose primary purpose is the recovery of metal and mineral products at a profit. An improvement in mining method, milling procedure, or metallurgical treatment is as truly a discovery of new metal as the finding of a new deposit. However, the future source of metals must depend primarily on new deposits.

The management member of this metal-producing team makes the decision of whether or not to explore. The attitudes of different governments make this decision difficult for it must weigh the technical problems involved against profits in the light of tax policies and other government regulations.

It is noteworthy that in recent years, exploration and mine development has prospered most in those countries in which government interference by direct

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regulation or by taxation has been the least. Canada and South Africa have enjoyed a surge of exploration and mine development equal to, if not exceeding, any in their past histories.

In contrast, exploration for nonferrous metals in the United States has decreased to an alarming degree, and for gold appears to have all but ceased. This surprising situation, according to a survey conducted by the Mining and Metallurgical Society of America, is the result of government policies influencing metal prices and of tax laws which add unnecessary risk to mineral exploration.

Efforts of the present administration to abolish the modest depletion allowances long established for the mining industry, appears at best ill advised when the critical need for metal is considered. Equally difficult to understand are the stockpiling agencies which purchase minerals only when they are in short supply and at high prices. This has contributed greatly to a confused and erratic market, and in turn has tended to restrict exploration.

Changes in the present tax law permitting exploration cost to be treated as expense, together with policies stabilizing metal prices in relation to other commodities would in times of adequate manpower produce a tremendous volume of exploration.

Research and studies by men in industry, and such organizations as the U. S. Geological Survey, state surveys, and universities, have added considerably to the understanding of ore deposits.

H. E. Hawkes reported that in addition to the basic research being done by the USGS and other organizations, over a dozen large mining companies in the United States and Canada have in progress or are considering geochemical studies.

USGS efforts have emphasized development of rapid methods of chemical analysis. Studies are aimed at understanding the processes governing distribution of metals in the vicinity of known buried mineral deposits, rather than in prospecting for new ore bodies. Experimental field work has started in the Coeur d'Alene and in selected areas in southwestern Wisconsin, Arizona, and Colorado.

Continued studies of rock alteration and its meaning in terms of ore are in progress by Sales and Meyer of Anaconda, Harrison Schmitt, Paul F. Kerr, G. M. Schwartz, T. S. Lovering, and others whose work has not yet received widespread publicity.

Closer collaboration between geologic effort and geophysical techniques is illustrated by extensive combined use in Canada and many other countries. In the United States, these methods were reported in progress in the Leadville, Colo. area, and in the Jerome district of Ariz., the work being supported by a number of large mining companies. Results of these projects have not been announced. E. N. Pennebaker noted that a feature of exploration at O'okiep is the close integration of geology and geophysics.

Considerable interest was expressed in the research of F. G. Smith at the University of Toronto on decrepitation techniques and possible applications to temperatures and depths of vein formation.

Spurred by sometimes bitter experience and realization of the limitations of the science, there is a healthy undercurrent of skepticism regarding current geologic theories. Harrison Schmitt's publications in 1950 questioning the present classification of ore deposits, and discussing the epithermal veins were examples. Edward Wisser's challenge to currently held theories of mountain building was another interesting departure. Short of anarchy, similar challenges have a valuable place in the more restricted understanding of a single mine. As E. de Golyer aptly expressed it; "many of our judgments of the value of individual prospects are based upon assumptions that certain theories are true. The theories may or may not be true and the assumptions are thus true or false. The history of the art of prospecting is strewn with the wrecks of what were once ruling theories, many of which were accepted because they seemed so reasonable."

James A. Noble's description of the mineralization at the Homestake mine was one of the important contributions to mining geology during the year. Another distinct contribution was publication of the report of the 18th International Geological Congress, part 7, "Geology Paragenesis, and Reserves of Ores of Lead and Zinc," edited by K. C. Dunham. Equally valuable are "Subsurface Geologic Methods" compiled by LeRoy, and the volume on "Applied Geology," a symposium compiled and edited by van Tuyl and Kuhn, both issued in 1950 by the Colorado School of Mines. Another valuable reference appearing was the revised and much improved textbook, "Economic Mineral Deposits" by Bateman.

U. S. Geological Survey work has been devoted largely to the valuable long-range projects of regional geologic mapping, and careful studies of mining districts. Considerable effort also has been expended in exploration for strategic minerals, both at home and abroad, and there has been further search for and study of uranium deposits in cooperation with the Atomic Energy Commission. Research on basic geologic problems has also progressed. In the present critical situation attention may be diverted from these activities to exploration projects.

Reorganization of the U. S. Bureau of Mines on a regional basis was effected during the year and examination, drilling, and sampling activities for many commodities was continued. Also in progress are compilations of factual data to serve as an atlas of mine development and exploration for various areas.

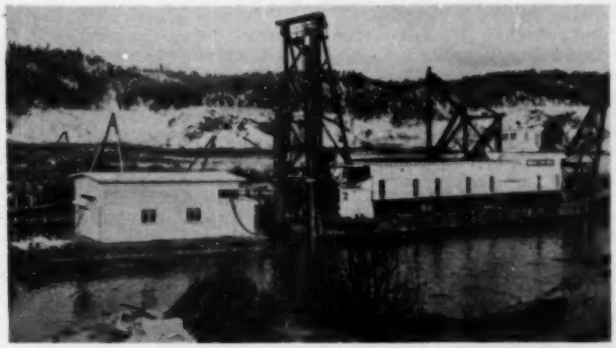
Unsettled world political conditions will probably force greater emphasis on production at the expense of exploration, and in this connection the policies of the Defense Minerals Administration will probably exert considerable influence.

Iron

Exploration culminating in the finding of the Cerro Bolivar iron ore deposit in Venezuela, is justly hailed as a great accomplishment. The team of Mack C. Lake, Folk Kihlstedt, H. Cayford Burrell, and their capable assistants, directed exploration resulting in the discovery of ½ billion tons of high grade open-pit ore. Of interest in this discovery was the use of aerial photographs and recognition of physiographic features as a guide to ore (see MINING ENGINEERING, February, 1950).

In the Labrador-Quebec range, since intensive drilling began in 1947, reserves now have reached some 400 million tons. Compared to even the great Mesabi range, the potential of this only partly explored deposit is enormous.

The volume of prospecting and development in the Minnesota and Lake Superior districts is greater than at any time since the opening of the Mesabi range in the late 1880's. G. M. Schwartz reported that a large iron sulphide body at the east end of the Cuyuna range was drilled with Minnesota and U. S. Bureau of Mines funds, and disclosed a deposit



Steep Rock is a recently discovered iron ore area. At left an electric cutter dredge is stripping overburden from the new Hogarth mine. Below, the Errington pit produced record tonnage in 1950.

aggregating millions of tons. Aeromagnetic surveys carried out by the Minnesota Geological Survey and the USGS have revealed what is probably a large extension of the Vermillion range.

Lionel R. Simard calls attention to Geological Survey of Canada, Paper 50-14 by H. S. Bostock, which mentions a large potential reserve of iron ore in Yukon Territory near the Bonnet Plume River. Reserves are also reported on Vancouver and Texada Islands, B.C.

Deposits in the Postmasburg area of Northern Cape Province are under development by the South African Iron & Steel Industrial Corp., Ltd., as reported by B. C. Alberts and R. A. Pelletier. C. A. Strauss indicated that the potential reserves of the entire Gamagara Rand must be enormous, as the relatively small area under development contains reserves estimated at 165 million tons. Raul de la Pena reported that iron investigations along the Pacific Coast of Michoacan and Guerrero continue to give satisfactory results.

Copper

The Copper Range Co. is developing its White Pine property in Michigan where drilling has revealed a deposit of remarkable uniformity and consistency. The deposit may produce more copper than has been produced from the Michigan deposits.

Other projects in the United States are directed toward extensions of known ore bodies or further exploration of previously known areas. Stripping at the Morris Brooks mine, Kimberly, Nev., and the announcement of a bedded replacement ore body by Magma Copper Co. in Arizona are examples.

Gaspé Copper Mines, Ltd., a subsidiary of Noranda Mines, Ltd., owns three deposits on the Gaspé Peninsula, Quebec. Copper Mt. containing some 20 million tons of 0.9 pct copper can be mined as a caving operation. Needle Mt. nearby, consists of a cone-shaped deposit containing some 15 million tons of 0.9 pct copper which can be open-pit mined. Underneath this deposit lies a richer ore body containing about 15 million tons of 2 pct copper which will be mined by underground methods.

Duncan R. Derry noted revival of the Chibougamau Lake area, Quebec, where four companies are drilling on and near Merrill Island and obtaining low to medium grade intersections over quite good widths. Noteworthy also are additions to reserves by Sherritt-Gordon. E. L. Brown stated that all the known nickel-copper ore bodies at Lynn Lake are tied into one major fault zone of pre-ore age, which helps explain why only two of the numerous basic plugs in the area contain ore.

Developments in African mines are outstanding. Ore is still being found both laterally and in depth in Northern Rhodesian mines, but the problem of water will probably trouble the operations throughout its life. Active diamond drilling based on closely integrated geological and geophysical examinations at O'okiep has resulted in finding extensions to a number of ore zones with consequent substantial increase in reserves, E. N. Pennebaker revealed.

At the Kilembe in Uganda where ore has been developed in four separate areas, the eastern area has recently received the closest attention. Duncan R. Derry stated that drilling and underground work during the year had developed a considerably increased tonnage of low to medium grade copper ore containing a small proportion of cobalt.

In Australian developments, Mount Morgan, Queensland, and the Cobar district of New South Wales are the scenes of greatest activity, according to J. K. Gustafson. At Mount Morgan, drilling has indicated some 10 million tons of ore with the deposit not fully outlined. H. J. C. Conolly reported that drilling was based on evidence of a structure similar to that known in the mine. In the Cobar district, New Occidental was said to have drilled large bodies of gold-copper ore, and announced a three-year development and exploration program.

Gold

There has been relatively little exploration for gold in the United States in 1950. In Australia, the Western Mining Corp. is continuing its Great West-

ern gold project. H. J. C. Conolly stated that drilling at Norseman was directed at extensions of ore which did not reach the surface, and was guided by inferences of the known structural pattern.

The gold field in Orange Free State, by far the most important gold development in the world, is the site of over a score of deep shafts. The mines developing from them will prolong the life of the Witwatersrand vicinity beyond this generation.

In Canada, the most impressive new development is at the property of Newlund Mines in northwestern Ontario, where underground work opened a length and grade of ore considerably greater than was expected from diamond drilling.

The Giant Yellowknife mine, Northwest Territories, remained one of the outstanding newer gold mines. Although the shape of the ore bodies is said to be unpredictable and the structural control still somewhat obscure, the grade reported over considerable widths is quite unusual, in places being one ounce per ton over widths of 75 ft or more.

Lead and Zinc

Three discoveries in the Coeur d'Alene district, Idaho, deserve mention. In the Page mine of the Federal Mining & Smelting Co., a promising new vein was discovered. In the Bunker Hill mine at Kellogg, a new body of high grade ore was found on 17 level. The Galena shaft development of Federal Mining & Smelting Co. and Day Mines is reported to have encountered mineralization on the bottom level.

In the Tintic district of Utah, USGS studies led to the discovery of a series of thrust faults hitherto unknown, H. M. Bannerman stated. Some of these faults project into the productive areas and are accompanied by late alteration, which perchance indicates hidden ore. One mining company is said to be drilling on its property as a result of encouraging indications found in a USGS test hole on one of these zones of alteration. At Park City, Utah, a major exploration project has begun in the joint area by Silver King and Park Utah.

In the Metaline district of Washington, Pend Oreille has its new incline shaft nearly completed, and one unit of its new mill completed. Sullivan Mining Co. is developing ore in the Metaline Mining & Leasing Co. workings; the project being designed to explore and extract ore indicated by U. S. Bureau of Mines drilling during the war.

New Mexico's Central district is undergoing much development. At the Ground Hog mine, two shafts are about 2000 ft deep, and considerable exploration and development are reported in progress. Kennecott Copper has recently completed the Oswaldo No. 2 shaft to a depth of 705 ft, with development and exploration being conducted on two levels. Exploration of fault-dike zones is being conducted from the Princess shaft of the U. S. Smelting, Refining & Mining Co.

At Silver City, N. Mex., U. S. Smelting has been carrying on an exploration and development program which appears to be successful. At Leadville, the U. S. Bureau of Mines resumed driving the drainage tunnel and is now in the Fryer Hill area, which in the early days produced a considerable tonnage of high grade ore from such famous mines as the Matchless and Chrysolite.

In Nevada the Fad shaft, idle since 1948 because of floods of water encountered while driving toward the ore zone previously found by drilling, is to be reopened. In the Wisconsin-Illinois field, development of ore bodies found during the war and shortly thereafter continues. Similar activity is reported from the Kentucky-Illinois zinc and fluorspar area. In Virginia and Tennessee considerable geologic mapping, diamond drilling, and soil analysis is being conducted in the search for extensions of previously discovered deposits. The Ocampo district of Chihuahua, Mexico, is reported by Raul de la Pena as the scene of an important discovery of silver ore.

Exploration by Société des Mines de Zellidja is meeting with obvious success in view of present and projected expansion of milling facilities. Société Nord Africaine du Plumb has been continuing exploration through two shafts in the area adjoining Zellidja, though developments have been delayed by water at the top of the productive Lias formation.

E. N. Pennebaker reported that at Tsumeb, South West Africa, geological mapping was continued in the vicinity of the mine, and diamond drilling to a depth of 750 ft below the 20th level continued to give favorable results. In the Broken Hill district of Australia, development of large tonnages of high grade ore and active exploration for more is in progress.

Canada can boast of important exploration for lead and zinc. Drilling at Pine Point on the south shore of Great Slave Lake continues. Exploration in Quebec on the Moulton Hill deposit, and on the Suffield property by Ascot Metals Corp. has been successful. Reserves announced tell of nearly half a million tons of excellent grade zinc, copper, lead, silver, and gold ore with the prospecting of a large tonnage of low grade ore held in abeyance. Golden Manitou Mines, Quebec, has found a new ore body.

British Columbia is witnessing development and exploration that is without precedent in the last thirty years, it is noted by M. S. Hedley. Mills are considered at Riondell, Spillimacheen, Ainsworth, Kaslo, and Fort Steele. The greatest development is that south of Nelson from the International Boundary to Ymir, where Reeves-McDonald, Emerald, H. B., and exploration north of the H. B. are proving up a large tonnage of zinc-lead in the limestone belt.

In the Yukon, silver-lead development at the Keno Hill property north of Mayo continues to grow, with the main production coming from two parallel veins.

K. C. Dunham writes that a new lead-zinc vein has been cut in the nine-mile sea level tunnel at Halkyn, North Wales, and exploration of this is in progress. At Llanrwst, North Wales, a successful program of geophysical prospecting has lead to discovery of new lead-zinc shoots at the Parc mine. In north Derbyshire, attempts are in progress to find lead deposits. At present the area is of interest only for its substantial production of fluorspar.

Uranium

Search for uranium continues the world over with the greatest intensity. In the United States, the Colorado Plateau, Colorado Front Range, Marysvale, Utah, and the Navajo Indian Reservation continue to be the most active and promising areas; activity continues on a smaller scale in the Boulder district, Mont., in the Coeur d'Alene district, Idaho, and in Baraga County, Mich. In addition, research continues toward utilization of low grade black shales and extensive phosphate formations.

Airborne Radioactivity surveying, a technique developed by the USGS and the Atomic Energy Commission, is a valuable tool for making quick

reconnaissance of large areas. The scintillometer has come into use and is regarded as an improved prospecting tool, and experimental flying with the scintillometer is in progress.

Manganese

In the United States, exploration for manganese is in progress from Maine to California, principally on deposits long known but little developed. The U. S. Bureau of Mines has conducted extensive drilling in Aroostook County, Me., and has undertaken underground development at Artillery Peak, Ariz. In California several large companies are showing interest in low grade manganese reserves. At present the Butte, Mont., mines furnish the greater part of manganese produced here. In Brazil the Amapa Territory manganese deposits are under development and exploration, and in South West Africa important exploration for manganese is in progress.

Nickel and Tin

Work is reported resumed at the Insizwa mine at Mount Ayliff, East Griqualand, where the occurrence is reported to be similar to that at Sudbury, and the ore bodies of impressive size. Sizable bodies of nickel are also reported from Indonesia.

The alluvial tin business in the Far East, in spite of political unrest, is making remarkable progress. In Bolivia, tin prospecting also continues and mining of lower grade ores is possible through sink-float milling process. Australian exploration for tin in Tasmania has resulted in sharply increased reserves. H. J. C. Conolly writes that at Storey Creek, "Tin-tungsten veins are associated with a pre-mineral fault, but not by any means as simply tension shears, and my bet was that the fault would make some more veins at depth. It did."

Tungsten, Beryllium, Rare Earths

C. D. Hulin pointed out that one of the most significant developments in metals in the United States was in the Hamme tungsten district of North Carolina. The Hamme mine is now operating at full capacity and is rapidly fulfilling geological expectations that it will become the most important producer of tungsten in this country.

Need for beryllium is great, and exploration is doubtlessly in progress, though it has received little public notice. There are reports of beryl production from the Bikata tin field east of Fort Victoria in Africa, and considerable production from South Africa and Southern Rhodesia, where the mineral was formerly discarded as worthless.

An important deposit of bastnasite in San Bernardino County, Cal., discovered in 1949 and investigated by D. F. Hewett, continues to attract attention. The discovery has been purchased by the Molybdenum Corp. of America and a 100 ft shaft and several hundred feet of crosscutting and drifting has been done. The USGS is mapping an area of about 20 sq mi.

Titanium and Diamonds

No new major discoveries of titanium minerals were reported in 1950, but development of earlier discoveries continued with vigor. In the United States, the Starke, Fla., operation is expected to reach its production goal of 120,000 tons of titanium oxide per year. Quebec Iron & Titanium Corp. has one of its five furnaces in operation at Sorel and by next year all five furnaces are expected to be in operation.

In Australia the Zinc Corp. group is now producing both zircon and rutile concentrates from an operation on Stradbroke Island. J. K. Gustafson noted that discovery of the deposit was the result of a geological study and drilling of a large low grade beach sand deposit.

Aluminum and Cobalt

New discoveries have not been announced, but the development of the Jamaica bauxite deposits of some 350 million tons in 1942 is in progress by Reynolds Jamaica Mines, Ltd. and Jamaica Bauxite, Ltd. In Africa, further investigations in the Volta River Region of the Gold Coast colony are reported.

Completion of the cobalt refinery at Garfield, Utah, scheduled for 1951, and completion of the concentrator at the mine, will permit operation on the large copper-cobalt property being developed by Calera Mining Co. at Blackbird, Idaho.

In Canada, revival of the famous silver camp of Cobalt, Ont., is one of the more spectacular developments. Eight properties are producing or are under development. While volume of production is not great, the silver content of the ore is high, and the demand for cobalt makes valuable a metal formerly regarded as nearly worthless. Africa's Union Minière du Haute Katanga continued to increase production of cobalt, and the Kilembe mine in Uganda is developing cobalt and copper.

Asbestos and Potash

In Ontario, aggressive prospecting continues along the 75 mile length of the ultra-basic rocks from Quebec boundary northwest to Cochrane, and Canadian Johns-Manville brought its new abestos ore body into production. Additions to reserves and development of new ore bodies continues in the Thetford and Black Lake districts of Quebec.

Prospecting in the United States was reported in the LeMoine area of California, and in Maine. The most encouraging U. S. development is that of the Vermont Asbestos Co. which completed a 2000-ton mill at Hyde Park, Vt., to treat rock from a new mine adjacent to one which has produced since the first World War.

Asbestos north of McDame Creek in northern British Columbia was noted by M. S. Hedley, although its position nearly 100 miles from the Alaska Highway will affect the economics of exploitation.

Intense development of the Carlsbad, N. Mex., potash area is being pushed by five companies, two of which, the Duval Sulphur & Potash Co. and the Southwest Potash Corp., a subsidiary of the American Metals Co., are new to the area.

From England, K. C. Dunham wrote: "The most important news in economic mineralogy in this country is the recent announcement by A. Fleck, director of Imperial Chemical Industries, Ltd., of the discovery at depths of 3675 to 4245 ft of Permian evaporite beds containing rich seams of soluble potash minerals. He estimates that exploration so far carried out indicates reserves of 200 million tons of KCl. It has not yet been decided whether to extract these deposits by mining or by brine pumping."

The author's debt to the many busy men who so generously supplied information is gratefully acknowledged.

METAL MINING

- better materials handling
- trackless equipment

by

Technical Committees, Mining Subdivision

Portable timber truck, used by Anaconda at Butte, fits on cage and is carried from level to level; is battery operated.

Photograph courtesy of MINING CONGRESS JOURNAL

LOW metal prices prevailing at the beginning of 1950 stimulated the search for improved mining methods. More experience was gained during the year with such new developments as the jackleg drill, millisecond delays as applied underground, trackless mining, and Diesel powered equipment. One of the outstanding innovations in mining practice was the starting of the Round Mountain "dry land gold dredging operation." The Government is now inviting the mining industry to open up every available source of new metal supply and this circumstance will undoubtedly speed the development of new machines. New methods will also result but it is doubtful if economic efficiency will be at its peak.

Developments in block caving centered largely around methods of ground support and improved methods of handling ore. Gerald Sherman reported that the Jeffrey mine of Canadian Johns-Manville Co. was brought into production early in 1950 using the Climax method of drawing through large openings into scram drifts; in which the ore is scraped to the haulage level below. A small experimental block was drawn employing this method at the Thetford mine of the Johnson Co. The first full-sized block was undercut and began drawing in September. It represents a shift from the small area draw points and grizzly drift caving of the porphry coppers to larger draw holes and scram drifts. The object of the change was to pass larger blocks of ore through the draw holes with less secondary blasting. Although production by the Climax method at this date has been small, according to Mr. Sherman, improvement has been obvious; production per man and per unit of horizontal area being greatly increased.

At Thetford mines there has been a trend toward using concrete instead of steel sets for drift support as concrete is cheaper and a steel shortage is foreseen. H beams have neither the surface bonding area nor the distribution through the concrete for efficient reinforcement. The use of H beams may still be necessary to hold heavy broken ground while permanent concrete is poured around them. It has been found possible at times to hold drifts by Guniting and this may be done occasionally for a short time until heavier concrete is placed. Pumpcrete is used by both the Jeffrey and Thetford mines. Pneumatic placing of concrete was formerly used at Thetford mines, but it requires greater care to prevent the segregation of cement and aggregate in cramped spaces.

Experiments with circular steel sets are being made for ground support in slusher drifts in connection with block-caving operations by Miami Copper Co. according to R. W. Hughes. High maintenance costs have characterized the use of timber sets and at times the drifts have been completely closed, resulting in unbalanced mine production and lower grade extraction. The circular steel sets are fabricated from 4-in. H beams, with an inside clearance of 6 ft 6 in. Results to date have been better than expected. Maintenance has been confined to the relief of side and top lagging and is done quickly. Side clearances are maintained for the passage of the scraper. While initial costs are higher than for timber, the lower maintenance costs have been more than compensating.

At Miami the use of conveyor belts underground has been extended. These are relatively short belts, 250 ft, installed in haulage drifts in heavy ground under producing stopes for the purpose of reducing maintenance costs and delays. The conveyors receive ore from scraper drifts and deliver it to the main haulage drift located in more favorable ground.

The block-caving operation at Ray is reported by R. W. Thomas to have received the addition of a second belt and now two panels are working in which the ore is transported by belt conveyor. Pan conveyors in the draw laterals feed the belts. Although sufficient time has not elapsed to substantiate the economy of this operation, it is known that there is a marked reduction in development expense.

Block caving was originally developed in the Iron Country but was more or less a failure in the early days. In the last two years block caving has again

Sees Transition to:

- bit selection
- packaged timber

attracted interest in this area. Algoma Ore Properties, Ltd., on the Canadian shore of Lake Superior is using it and other companies including the Cleveland-Cliffs Iron Co. have experimented with it recently. Pickands Mather and Hanna at Iron River, Mich., are both considering block caving.

R. H. Wightman of Riverside Cement Co., Calif., reported that recovery of limestone by block caving on the first cut was nearly completed and that the company is in the process of designing a different method of recovery for the remaining underground limestone. The new method will yield higher efficiencies and lower cost than could be realized by block caving.

Shrinkage and Square Set Stoping

S. S. Goodwin, manager of mines, the New Jersey Zinc Co., reported random changes and variations from normal practice which came to his attention. At the Sterling mine, Ogdensburg, N. J., he noted that rocker-type cars had been substituted for gable-bottom cars because they were better adapted to handling chunks of ore from shrinkage stopes. The Mt. Hope iron mine, N. J., is planning to change from shrinkage stopes along the strike to sublevel stopes in order not to tie up so much broken ore; to increase flexibility in meeting sales demands; to reduce dilution of ore; and to increase the length of blastholes to 40 ft. Scrub Oaks iron mines in New Jersey has abandoned sublevel stoping in favor of shrinkage stoping. Long holes for shrinkage stoping were tried and proved more expensive; but long holes for slabbing pillars into empty stopes are still in use.

A Nevada mine working a 200-ft thick orebody has saved money by using a combination of shrinkage stoping and sublevel stoping instead of complete sublevel stoping. Only the pillars are taken by sublevel stoping.

In vein mining, distribution of supplies and tools to the working places has always been an expensive and time consuming operation. Supplying timber to square-set stoping operations is one of the outstanding examples. Packaged timber to eliminate handling one piece at a time is receiving trials at Butte, Coeur d'Alene, and Bisbee. When fully developed this practice will save time and labor, permit compact storage on surface and underground, and increase cage carrying capacity.

In the December 1950, *Mining Congress Journal*, T. S. Veazey, Jr., reported the status of the technique as follows: (1) Lagging and dimension timber for five mines being handled by large lift trucks; (2) central handling yard under construction; (3) two-ton grab jaw truck is used for loading steel-strapped packages of lagging in crates; (4) a compact portable fork-lift truck to be transported on cages and able to unload bundles at underground stations; (5) studies on cage loading methods and practicability and cost of changing from round to slabbed or squared mine timber which is more adaptable to packaging.

At Bisbee packaged timber is tilted on and off the cage by a small hoist mounted under the bonnet of the cage. Timber handling costs may be 65 to 70 pct of what they formerly were. The Sullivan Mining Co. is using a revolving head grab-jaw attachment on a lift truck. Sawed lagging, headboards, and dimension timber is loaded onto cages with this machine which is adapted to the large cage decks at that mine. On the transfer level between the Hecla and Star shafts two battery-powered Clark trucks equipped with grab jaws are used for unloading cages and reloading timber on trucks for transportation to the Star shaft, where they are unloaded onto the cage at the Star shaft.

Drilling

All phases of drilling practice received study in 1950 including bits, steel, machines, and air pressure. For many years the detachable multiple-use bit has been standard but in recent years tungsten-carbide insert bits, both detachable and intraset on conventional steel rod, and the one use or throw-away bit have been coming into vogue. The mine

Joy shuttle car dumping into mine car at the Desloge mine of the St. Joseph Lead Co. in Missouri.

operator has an opportunity today to select from a variety of bits the type which will be most economical for his ground conditions.

In shaft sinking where labor costs are high and the sinking cycle must be maintained the tungsten-carbide bit is used in hard ground. It is also replacing diamond-drill bits for drilling long blastholes in stoping principally because of the high cost of diamonds. This latter change was not easily made as is evident from reports from the Holden mine of Howe Sound. Considerable engineering was required to select and develop connections for drill rods, size drilling machine, and hole cleaning. The following equipment is now used at Holden for drilling long holes: 4-in. diam piston machine, 2-in. tungsten-carbide insert bits, Type 2 couplings, 1⅛-in. round steel, 1¼-in. lugged shanked adaptor steel, and independent water swivel.

Bunker Hill mine is employing single-use bits to drill in abrasive quartz and quartzite. Starting with 1¾-in. bits, five changes are used at 1/16-in. intervals. The bit cost is less than 1c per ft. Hollow round alloy drill steel is used, 1⅛ in. diam. The adoption of alloy steel drill rods required closer temperature control in annealing and tempering. At Pend Oreille tungsten-carbide bits are giving lower labor cost even in softer ground partly because of time saved in not having to change bits.

S. S. Clarke of Eagle-Picher reported continuing tests on alloy drill steel and one use bits with encouraging results. The bits are being designed by a manufacturer to meet the high abrasiveness of chert. The objective is to perfect a bit that will drill a 10-ft hole before discarding the bit. Two types of alloy steel are being tested, 1⅛ and 1¼-in. hollow round. The bar breakage is low while the shank breakage is high but not enough to offset the low bar breakage. Another interesting test is being conducted on the use of electric steel tubing in place of drill steel. This test is showing some favorable results and will be continued.

Philip D. Pearse and Warren W. Samar reporting on mining developments in a recent paper on the Menominee Range remarked: "It appears that the tungsten-carbide bit on the Menominee Range has no real advantage over the multiple-use bit or the one use bit. In hard ground the tungsten-carbide bit has the advantages in time and cost; but in the usual Menominee Range ore, there are no advantages. Recent tests show that the one-use bit may have an advantage over both the standard multiple-use bit and the tungsten-carbide bit. The intraset bit is still being tested and has been adopted for limited use."

An example of tungsten-carbide bits in a small mine is described by C. H. Vivian in December 1950, *Compressed Air*. In describing the operation of the Hamm tungsten mine in North Carolina he states that 1½-in. series 13 carbide bits and alloy-steel drill rod are used. Miners are issued two complete sets of bits plus one spare as they go on shift. Development work in granite or vein quartz, where three rod changes are made to drill a 6-ft hole requires seven bits. The bits are returned at the end of the shift and are resharpened by the lamp man, during the night, who uses a Jackbit grinder equipped with a Carborundum wheel. In the first six months of 1950, 1851 bits drilled 229,535 ft. Carset bits drill an average of 124 ft before needing attention as compared to 12 to 18 in. for standard steel bits.

The work of mining was made easier in 1950 by wider acceptance of the new lightweight jackleg drilling machine. This type machine was introduced into Canada by the Swedish firm, Sandvik Steel Inc., making the Cormorant drill. Since then American manufacturers have designed adaptations of the jackleg drill. Its outstanding features are its light weight, fast drilling, ease of setting up, and flexibility. These machines are frequently used with alloy drill steel and tungsten-carbide bits. The Swedish machine is reported to be superbly integrated as drill, steel, and bit are engineered to work together. For small operations the jackleg-type machine is unsurpassed because of its flexibility and comparatively low investment cost. Smaller diameter holes are drilled, resulting in powder saving. In driving large diameter headings in hard rock the drill jumbo with heavy hard-hitting Leyner drills is still the favorite but for one-man narrow headings in hard rock the jackleg machine is receiving careful consideration.

A wide variety of jumbos are on the market offering rubber tired, caterpillar, and rail machines. These feature hydraulically operated booms for easy positioning of drills and long feeds. The tungsten-carbide bits are used with long-feed drilling because they minimize gage loss and stand up so that bit changes are not necessary for the length of a hole. Mr. Clarke reported that a drill jumbo with telescoping mast which can extend to a height of 65 ft is in use in several of the Eagle-Picher mines, and doing excellent work taking down roof up to 30 ft above the height of the mast. The jumbo is also able to climb broken rock piles. Another application is for collaring raises in high ground. This saves many feet of raising by eliminating the necessity of starting the raise in the wall rock.

Millisecond delay blasting caps have received wider cognizance in 1950. In quarry work they have shown good fragmentation, minimum throw, and practically no vibration. In underground mining they have been used in stoping more than for development work. Where big blasts are being set off such as in longhole stoping methods they have been used successfully. Wing Agnew of the U. S. Bureau of Mines has experimented with millisecond blasting in raises at the Mt. Weather station. He reported a saving in powder consumption, fewer holes, and elimination of burn or V-cuts; all holes were drilled perpendicular to the face. Pearson and Samar reported that electric blasting was receiving wider acceptance on the Menominee for increased safety and to minimize misfires from wet conditions. Milliseconds have been used successfully in longhole ring blasting to reduce concussion and improve fragmentation. A saving of 20 pct in powder consumption on main level drifting has been realized by one operator. Other Menominee operators have reported bootleg holes with the short delay blasting caps. "These delays have a decided advantage and gradually will be used in more and more applications," according to Pearson and Samar.

Large powder, 2x16 in., has been introduced on the Menominee and is reported to increase the burden per hole, improve breakage, and increase the tons broken per lb of powder.

Mechanical Loading and Conveying

At the St. Joseph Lead Co. mines in Southeast Missouri, according to N. A. Stockett, about 90 pct of the ore is loaded by St. Joe electric shovels. Type 18 HR Joy loaders are also used for loading into 60E

Joy shuttle cars. A 43-in. high Jeffrey shuttle car was put into operation in 1950. In development work, more Conway shovels are used than any other type of loader. Portable ramps and Eimco shovels are also used. At the St. Louis Smelting & Refining Co.'s mine at Fredericktown, an Eimco shovel with caterpillar treads has recently been installed underground for loading Euclid trucks.

Milnor Roberts reported information on loading and conveying at the Holden mine furnished by W. S. Phillips, chief engineer. Widespread interest in this country and Canada in the method of direct draw-point loading into cars with overhead mucking machines has led to studies in an experimental stope on cost and over-all mechanics of operation by this method. This stope has two drawpoints. Access from the main haulage in the wall rock is through a crosscut with branches to the draw points in the ore zone. An Eimco 21 overhead loader at the draw point loads directly into a mine car which is brought up to it singly. No cost figures are available yet but an initial direct saving occurs by the omission of ore passes and loading chutes. The impression gained thus far is that for a stope of 60 to 80,000 tons the method might show a cost lower than average but for a large stope it could not compete. An experiment on a concrete-lined slusher drift is being conducted but not enough ore has been handled to give results. The experimental drift is 7x7 ft inside concrete and has rails laid in the floor and in the walls opposite the draw points.

Diesel motive power is receiving detailed consideration in the Carlsbad area. A start is being made by one company putting a Diesel bulldozer underground. An especially designed scrubber is used to handle the exhaust fumes. The same company is designing a Diesel drive for shuttle cars and is studying Diesel haulage as an improvement over electric and as an alternate for a belt conveyor system. The mining plan for the conveyor system calls for an ultimate length of four miles for the belt conveyor which will be fed by panel entry conveyors. Diesel-driven shuttle cars will load in panels and dump on panel conveyors. Fragmentation tests are being made using millisecond delays. If fragmentation is not sufficient to hold lumps to conveyor size, a portable crusher will be used at the shuttle-car dump point. Two styles of crushers have been designed but have not been tested. Another company in the potash area has a continuous-type miner on order.

Dredging

H. A. Sawin reported that placer mining for gold is at a low point in the United States and Alaska because of price. Gold dredges in South America are more active. Operators of tin dredges in Malaya and other parts of the Orient are experiencing a boom period because of the high price for tin but are operating in the face of domestic difficulties incidental to the disturbed conditions in that part of the world.

A free-milling alluvial gold orebody is being mined at Round Mountain, 57 miles northwest of Tonopah, Nev., by a method unique to gold mining called "dry land dredging" by some. A bucket-line dredge could not be used because of the great thickness of the deposit, averaging over 200 ft, the large number of boulders, the steep slope of the bedrock, and the fact that the ore was too porous to hold a dredge pond. The mining operation, as described by Howard Waldron in the June 1950 *Mining World*, employs a dragline on top of the bank to work ore down into the pit with a 7000 lb scarifying plate swung from the end of the boom against the bank. An electric shovel in the pit loads ore into a hopper on the end of a pendulum conveyor section which carries ore to a crusher-car unit. The pendulum conveyor gets its name from the fact that it is moved in an arc to mine a half circle of ore in the pit from one placement of the crusher car. The crushed ore is taken out of the pit by conveyor and is stockpiled. Ore is drawn from the stockpile and taken by conveyor to the fixed dredge-type mill which is rated at 17,000 ton per 24 hr. Tailings are carried by two boom stackers to tailing piles that are clear of the plant site.

At the new Round Mountain Dredging Corp. gold project in Nevada, a rail-mounted crusher feeds conveyor belt. It moves further down into pit as digging progresses.

More widespread use of solar thawing methods for preparing relatively shallow frozen placer deposits for dredging in Alaska is reported by Ernest N. Patty. He said that higher steel costs are causing more dredge operators to use lip segments which are welded on to worn bucket lips to build them up to shape. To combat rising costs some dredge operators are using higher bucket-line speeds, particularly for the top gravels. For example the three dredges, which are operated by Gold Placers Inc. in Canada, have gear shift arrangements which permit digging the relatively barren top gravels at 30 buckets per min and reducing to 20 bpm when approaching bedrock. Screen and pump installations are designed to handle the extra amount of gravel when the dredge is in high speed. Mr. Patty also reported that U. S. Smelting Refining & Mining Co. at Fairbanks had developed mechanical point-driving machines.

During the last week of August 1950 the American Mining Congress held a metal mining equipment exposition in Salt Lake City which contributed materially to an exchange of ideas on equipment. It is reported that many of the demonstration models were sold off the floor which indicates the need for these shows. Many improvements in equipment and methods will be made in 1951 because of expanding mine production from new orebodies and extensions of old ones.

A view of the mill at Shook & Fletcher Supply Co.'s Blackburn mine in Alabama. Inset shows Wemco Mobil-Mill being installed.

Beneficiation in 1950

Low grade ores dwarf high grade, tonnage wise. Bigger and improved-design machines feature modern concentrators. Flowsheets becoming more complex.

by Grover J. Holt

A GREAT many developments have taken place in the field of minerals beneficiation in 1950. New plants have come into production utilizing various processes and flowsheets for the concentration of almost any mineral which can be named. Research laboratories are working continuously to improve methods and to develop new processes in order to exploit lower grade ores, which in aggregate tonnage dwarf the possible output of the high-grade deposits mined in the past.

Equipment manufacturers have kept pace with the development required in new equipment, and it appears that the size of grinding units, as an example, are exceeding even the most optimistic hopes of the early research men. Oversize ball and rod mills are being installed for grinding, and units such as the Dutch State Mines cyclone appear to have left original laboratory calculations far behind. The diameter of these units was originally measured in inches as compared to the present-day specifications measured in feet.

In the field of crushing it appears that hydraulically supported gyratory crushers have definitely come out of the development stage and are spreading in use. A new unit called the Hydrocone is being installed in the Pend Orelle Mines and Metals Co. mill at Metaline Falls, Wash., and the Interstate Iron Co. plant on the Mesabi Range.

The Aerofull mill has appeared on the market and is being used in certain industries as a combined crushing and grinding unit. Birdsborough Co. now

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has a super-jaw crusher unit 66x84 in. of approximately 1000 tons per hr rated capacity.

The principle of the hammermill has been developed into a double impeller dual-impact breaker, and among the recent installations is that used by the Steep Rock Iron Mines, Ltd. in Canada. This machine gives an extremely great size reduction in one pass.

Interesting development work is under way by Consolidated Mining & Smelting Co. at Trail, B. C., where a large rod mill using a 90-ton charge with rods measuring 4½ in. diam is in use. It is reported that after 285 days of operation, the lifter bars in this mill appear to have 50 pct life remaining after handling almost 2,500,000 tons of ore. It is reported that this mill has been handling tonnages up to 9000 tons per day, operating at speeds varying from 13½ to 19 rpm, developing shell speeds up to 580 to 600 fpm, or about 81 pct of critical speed. It is reported that these large rods simulate the work of a stamp mill. The lifters drive the up-moving mass of rods against the down-coming to simulate the action of the stamp mill. Ball milling seems to be taking on its share of growth and size with the installation of four 10½ ft diam x 14 ft ball mills by Kennecott.

Ball Mills Increase in Size

In the field of grinding Bond and Wang, who have been dissatisfied with the Kick and Ruttenger theories, have evolved one of their own; namely, the strain energy theory and have derived an empirical equation for total energy input in crushing and grinding. The theory assumes that most of the energy goes into particle deformation and reappears as heat, rather than into the production of new surface energy, but conversely the new surface area produced is roughly proportional to the energy input. In support of this, preliminary tests with a Schillenger ball mill enclosed in a calorimeter indicate that perhaps 90 pct of the net energy input appears as heat.

Studies continue at the Tennessee Copper Co., where large diameter slow speed grinding mills have been used at high dilution, resulting in substantial savings and power cost. When the ball diameter is less than 1 pct of the mill diameter, slow speed and high dilution cause important changes in the ball action and mill charge contour.

W. F. Baine, general manager, Arizona Barite Co., inspects a 4x25-ft spiral classifier handling the discharge from a 5x8-ft ball mill.

Pend Oreille installed a 10 ft diam x 8 ft mill, using a charge of 4 to 5-in. diam balls with a grind of 85 pct —200 mesh. The opinion rendered in the latter case was that "large diameter ball mills with trunion overflows give cheaper costs than large diameter grate mills." In this case it is stated that investment in balls has been lowered by the use of cast iron vs steel or steel alloy balls. It is the opinion of one correspondent that comparatively high lifter bars will be necessary on large diameter mills. As usual, any gathering of mill men ends up in a symposium on the effect of various types of liners in ball milling. However it is reported that at Yellow Pine the life expectancy of liners with replaceable lifter bars will be approximately 1 million tons vs 80,000 tons of life for regular wave-type liners. It was also reported that the above-mentioned result has not been demonstrated for lesser diameter mills running at comparatively high speeds.

A recent application of the center peripheral discharge rod mill has been made for the manufacture of specification sands and for light grinding. This mill, fed equally at both ends, supplies high tonnage capacity for low ratio of reduction.

Lake Shore has converted ball mills to pebble mills and reported a substantial saving in grinding costs, using sized ore as grinding medium. The maintenance of pebble load is semiautomatic and accurately controlled. Grinding must necessarily be limited to ores having sufficient hardness to furnish the grinding medium. This development appears to hold interesting possibilities for ore which fits this condition.

In fine grinding, down to the micron sizes, it is reported that Allis-Chalmers is doing considerable laboratory and test work on the design of a vibrating ball mill.

Gouvernor Talc Co. is using 14 fluid energy mills for producing pigment-grade talc in sizes down to 6 microns and finer. In these mills crushed talc is fed into a chain-link hollow casing in the lower section of which are nozzles through which preheated compressed air is expanded. The particles are whirled at a high velocity through the casing and are reduced by impact and attrition upon each other and on the casing. Provision is made at the top of the inside wall for controlled withdrawal of ground products.

Sink-float separation continues to grow in its utility, as indicated by the various minerals being treated. Particular gains have been made by Heavy-Media separation, using magnetic medium. During the year nine new plants treating coal were started, three new plants treating iron ore, three new plants each treating zinc, chromite, and diamonds. At the present time there are 65 Heavy-Media plants in operation and it is reported that 28 more are scheduled to start.

The Premier Diamond Mining Co. of South Africa

At Cananea Consolidated Copper Co., these eight 10x10-ft Marcy ball mills are each working in closed circuit with two Akins classifiers. A spare mill is in repair bay in foreground.

started a large sink-float unit treating diamond-bearing ground in 1950. New sink-float plants treating iron ore have been placed in operation by Shook & Fletcher in Ala., and the Interstate Iron Co. on the Mesabi Range. The use of sink-float in the treatment of coal progressed by leaps and bounds in 1950, both in the United States and abroad.

Variety in Sink-float Vessels

Originally sink-float separatory vessels consisted largely of cones, which were followed by the Akins-type separator and the Hardinge concentrator. Several installations have been made recently utilizing the drum-type separators of the Link-Belt and Wemco type. In sink-float work where ferrosilicon is used as a medium, several new magnetic separators have been placed on the market of the drum type. Test work is being carried on in several plants testing these new separators.

The Dutch State Mines cyclone has been used for fine ore Heavy-Media separatory work by M. A. Hanna and it is reported that in 1950 many improvements in technique were made with the result that one or more plants will be started in 1951. Drum separators have also been used on pilot-plant scale in treating these so-called "fine ores", particularly in iron ore for the treatment of —8 mesh material.

Recovery of fine coal by flotation is increasing. It is reported that a 125-ton per hr plant was started by the Philadelphia & Reading Coal & Iron Co. at its Locust Summit Central breaker near Mt. Carmel, Pa. It is understood that this makes five flotation plants in operation on anthracite and three on bituminous coal at the present time.

Chemical Construction Co. has developed a process for removing elemental sulphur by flotation which appears to be of considerable merit.

Hukki and Runolinna have effected good concentration in recovery of gold and silver from anode slimes by flotation. It is reported that in connection with the Greater Butte project, scouring and desliming will be necessary to treat oxidized ore. Soluble copper will be recovered by sponge iron treatment in the proposed plant.

Several of the iron ore concentrating plants of Minnesota are using the Humphreys spiral for fine ore treatment, and construction was started by M. A. Hanna on a new plant containing 216 spiral units.

During 1950 test work was carried on in the treatment of fine iron ore, using the Weinig concentrator, and a second Weinig unit will be placed in operation during 1951 on the Mesabi Range.

A new drum-type magnetic separator, utilizing Alnico magnets has been developed and a new concentrating plant at Sydvaranger at Kirkenes, Norway, is being equipped with these units. This is the first commercial installation of this magnetic separator.

The cyclone has reached its maximum growth in size to date at the new Sydney plant treating matrix of phosphate rock. Five new large size units, 4 ft in diam, are used for desliming flotation feed. These units were devised to eliminate a tremendous gallonage of water so that thickening could be performed in the standard type thickener. Cyclones are being used by the National Lead Co. at Tahawus, N. Y., for desliming at about 15 microns. Cyclones are also reported as doing good work in desliming and clarification at Telluride Mines as well as many of the coal plants throughout the country.

Screen Design Changes

Deister has modified its diagonal-deck coal washing table by venting the back board which is claimed to provide 8 ft of additional refuse discharge capacity. The new Concord washer of TCI has 64 of these tables. This table appears to have possibilities for low ratio of concentrating ores such as iron and phosphate as well as coal although no such installations have been made.

The Hydroscillator developed by the Dorr Co. was used successfully at the Tennessee Copper mill for classification work and is currently being used in the phosphate fields for the same purpose.

Fine granular coal sludge and coal flotation concentrates are being dewatered on vibrating screens with special decks. One operator prebeds screens with —¼-in. material and sends the undersize to hydroseparators in closed circuit with the same screens. The hydroseparator overflows at 270 mesh to a thickener from which the sludge is pumped back to the screens as a third layer. The circuit is completely closed. Another screen operates on hydroseparator and thickener underflow without prebedding with coarser material. A third screen dewaters flotation concentrates without prebedding. It is reported that moisture of cakes are comparable to vacuum filter performance. This radical dewatering or filtering technique is said to depend on mass overcrowding of the screens by means of a circulating load. The mineral particles key together to form filter cake before they pass through the relatively coarse opening of the screen.

Several new types of slurry pumps for handling large gallonage of coarse materials suspended in slurry have come on the market recently. Increase of pumping efficiency on this type of material is claimed.

The use of rubber-lined and neoprene-lined pipe and equipment is increasing and savings are reported to outweight installation cost about three to one.

Pumping has been developed into a long-distance transportation unit by the Virginia-Carolina Chemical Co. A pipe line has been installed from a new

mining area and phosphate matrix is being pumped for a distance of five miles in the Florida phosphate fields.

During 1950 horizontal screens with so-called re-pulping pockets on the screen deck have been used in the Florida fields for the washing of phosphate rock. It is stated that these re-pulping pockets are extremely helpful in this particular type of screening.

Electrically heated screen decks developed by the Tyler Co. are being applied commercially with several units in operation. It has been reported that in screening certain sticky materials with 14 pct moisture through a 20-mesh square opening there is absolutely no blinding when the current is on and complete blinding when the current is shut off. This type of screening appears to have a promising future where semidry screening is attempted.

Innovations in Conveying

Conveying of material by belts is attracting considerable attention from the development angle after remaining static many years. Several companies have proven in the past year that a conveyor belt can be twisted 180° on the return flight and thereby place the clean side of the belt down against the return idlers after it leaves the head pulley and then reverse the belt again 180° before it makes contact with the tail pulley. This eliminates a great amount of cleanup work caused by the spillage of material on the return flight. One such installation is now being installed by Cleveland-Cliffs Iron Co. in Michigan.

National Mines Corp. at Morgantown, W. Va., has developed a new type of belt conveyor which can make a turn 45° in horizontal plane. This appears to be a radical change in the field of conveying. National has also installed a standard conveyor system two miles in length.

Carnegie Illinois Steel Corp. is developing a steel conveyor belt and accessory equipment, including automatically aligning idlers.

A new 45° self-aligning return idler has demonstrated its ability to retain belt alignment in many fields. One user reports that it is "the only idler that has been able to steer the 900-hp 740-ft lift belt in Alabama without causing belt damage."

A new 1500-hp steel cord conveyor belt is being used by the Chicago, Wilmington and Franklin Coal Co. in Illinois. Operators have developed a splicing technique to remedy one of the early difficulties found in splicing steel cord belts.

In the field of launders, portable gun-type welders are used by a southern preparation plant to weld threaded studs to steel parent launders. The continuous rubber liner strips are thus held in place by pressed steel clips bolted to the studs. It is stated that installation is fast and inexpensive.

Agglomeration of fine materials resulting from various processes of concentration has become one of the major problems in metallurgy today. Sintering has held the center of the field but pelletizing in its various forms is coming to the forefront rapidly. Commercial sized pelletizing furnaces are in operation at the Armco plant at Ashland, Ky., the Erie Mining Co. at Aurora, Minn., and the Bethlehem Steel Co. at Lebanon, Pa. Since almost any concentration process in the development of low grade ores requires fine grinding resulting in the necessity for agglomeration, metallurgists are watching these developments with interest.

The commercial-sized installations today consist of shaft-type furnaces. Allis-Chalmers is experimenting with a traveling grate upon which the pellets are laid for the purposes of heat absorption and hardening. No commercial installations of the latter type are in action at the present time. A rotary kiln, as well as a sintering plant, is being constructed by the Oliver Iron Mining Co. at Virginia, Minn., in order to compare the rotary kiln with the sintering process for agglomeration of certain iron ores.

Agglomeration by extrusion in shaft and other types of furnaces is being tested, as is the possibility of extrusions without heating to the degree necessary in these furnaces. During 1950 construction was started on a pilot pelletizing unit by Cleveland-Cliffs at their research laboratory at Ishpeming, Mich.

A great deal of test work involving the use of FluoSolids has been carried on in 1950. The Golden Cycle Corp. has installed a new FluoSolids roasting plant for use on Telluride gold ores. It should go into operation shortly and several similar installations are contemplated in Canada.

The Copper Range Co. is contemplating a sulphating roast on their White Pine concentrates followed by leaching and electrolytic precipitation of the copper. San Manuel is reported to be considering such an installation.

The last session of congress appropriated $600,000 for construction of a pilot plant to develop beneficiation methods for the extensive Artillery Peaks manganese deposits in Arizona. The new Lord flotation process for iron and manganese may be used in this plant for concentration, followed by a hydrometallurgical plant for the production of high grade manganese nodules from the ore which is about 10 pct manganese.

Improved Automatic Controls

The use of automatic controls in metallurgical plants has been given great impetus in 1950, and research work is still going on to promote the use of these controls to a greater degree. The International Minerals & Chemical Co. is using automatic controls on pumping equipment in Florida and are also using controls to regulate the pH automatically in the phosphate flotation circuit.

Systems are being developed based on power input of the classifier to regulate the feed to the grinding circuit. The increases in circulating load and consequently in classifier power consumed decrease the feed rate. Allis-Chalmers is developing automatic controls to limit the feed to the grinding circuit based on the turbidity of the classifier overflow.

Automatic controls of various types are in use and being developed for the control of pH, reagent additions, tonnage controls for pumping, level controls in bins and tanks, control of tonnage rate fed by feeders, hydro and classifier tonnage controls, as well as many others. Combined Metals Reduction Co. is working on an electronic meter for measuring circulating load and it should be noted that this company has contributed substantially toward the field of automatic controls in many phases of metallurgical operation.

In addition to automatic controls on types of equipment mentioned above, it is reported that automatic signal systems reporting to central points, mechanical and electrical interlocks, and extensive use of protective devices such as electrically interlocked bearing thermostats on big motors, reducers, bearings and other critcial equipment are paying their way where properly applied.

Bolts held up roofs as mining machines went on to set new records, but rising labor costs still plagued operators.

by C. F. Hardy and D. R. Mitchell

COMPARATIVE labor peace with only one widespread work stoppage has marked 1950 in the coal industry. This peace has been reflected in the output of bituminous coal and lignite which will be in the neighborhood of 508 million tons, a substantial advance over the 437 million tons produced in 1949. Anthracite production is also expected to be materially higher than that of last year.

The stocks of bituminous coal on hand are over 70 million tons, although consumption and exports have exceeded production for several weeks and may continue to do so for a considerable period in the future.

In the field of technological advances, 1950 has been a year of steady growth, rather than any outstanding major innovation. Research and experimental work in all phases of coal production and utilization have continued to show definite gains.

The users of coal have continued to build new and more efficient coal burning equipment. Several new installations of cyclone furnaces have been made during the year. The use of reheat boilers to reduce the cost of electric generation has accelerated. The expansion of public utility electric generation has proceeded at a rapid rate as has the load on these systems.

The need for greater capacity has led to the selection of high capacity coals which will deliver the most heat with the least maintenance and interruption to service.

The coal industry is in good shape to carry the added burdens of the defense effort or even total war. The added capacity in mining and preparation since 1945 is the one bright spot in the months and years ahead. Regardless of what comes in defense or war efforts, coal will again carry more than its share

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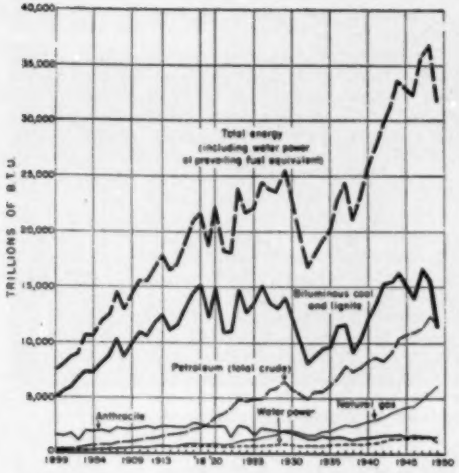
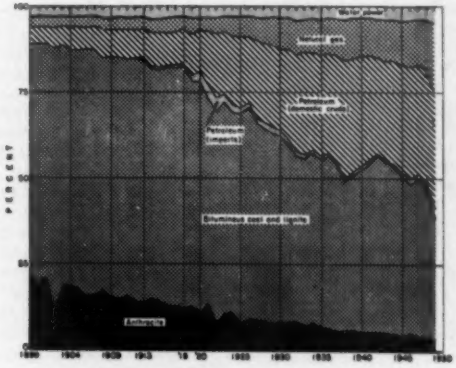
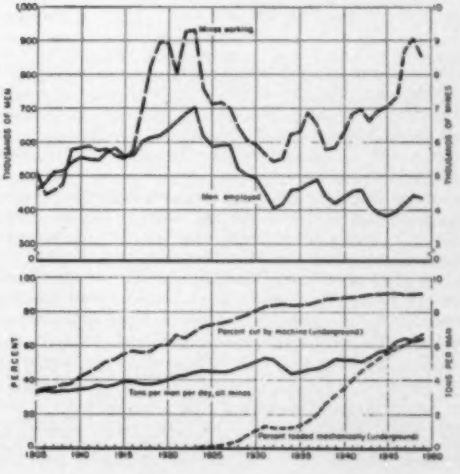

TRILLIONS OF B.T.U.
Total energy (including water power at prevailing fuel equivalent)
Bituminous coal and lignite
Petroleum (total crude)
Anthracite
Water power
Natural gas
1899 1904 1909 1913 '18 '20 1925 1930 1935 1940 1945 1950

Above, the annual supply of energy from mineral fuels and water power in the U. S., 1899-1949.



Left, percentage of total Btu's contributed by the several sources of energy in the U. S., 1899-1949. Below, trends of employment, mechanization, and output per man-day at bituminous and lignite mines, 1905-1949.


THOUSANDS OF MEN
Mines working
Men employed
THOUSANDS OF MINES
PERCENT
Percent cut by machine (underground)
Tons per man per day, all mines
Percent loaded mechanically (underground)
TONS PER MAN
1905 1910 1915 1920 1925 1930 1935 1940 1945 1950

of the load if labor does its job and the necessary supplies are available.

Electric power utilities and coke plants again as in past years show the greatest gains in the use of coal. Railroad locomotive coal has continued to drop during the year. However, if the all out defense effort calls for the greatest amount of motive power with the least use of critical fuels, railroad locomotive fuel may reach its former importance in the coal-consumption picture. Any increase in the demand for coke for increased steel production can be supplied by the coal industry.

The same factors which make the coal industry ready for the war effort, if it comes, have improved its competitive position in the peacetime economy. However, it is true that in the past several years every reduction in the cost of mining through better machinery and more efficient practices, has been practically offset by increased labor costs. Such an anomalous situation cannot long continue.

There is increasing pressure against the practice of dumping natural gas for use under power boilers at ridiculously low prices. Today, coal's competitive position with fuel oil is also improved.

To sum up, insofar as the United States is concerned, it has sufficient coal and sufficient available production to take care of the foreseeable future. It is the only country in the world that has an excess coal production. All other coal producing countries are short of coal production and several are importing increasing amounts from the United States. Technological advances as have been reported and discussed at the AIME meetings, are the most important single factor in the improvement of the coal industry's picture, even though they have been offset to a certain extent by unenlightened labor leadership and unenlightened marketing policies of coal's principal competitors.

Mechanization of bituminous coal mines increased percentagewise at a rapid rate during the year. Approximately 80 pct of the total production originated at strip and mechanized underground mines.

Two outstanding developments occurred during the year: (1) The widespread interest and acceptance of the continuous mining principle and (2) the acceptance of roof bolting as a major step forward in controlling mine roof and in lowering costs.

Three types of continuous mining machines were in use by year's end, two others were being tried in model form, and two others are reported to be designed and ready for construction. Operating results

Table I—Trend in Daily Earnings of Coal Mine Workers

Effective Date	Underground Workers Maximum	Underground Workers Minimum	Outside Day Workers
Oct. 2, 1933	5.80	4.36	3.84
Apr. 1, 1934	6.20	4.76	4.24
Oct. 1, 1935	6.90	5.26	4.74
Apr. 1, 1937	7.60	5.76	5.24
Apr. 1, 1941	9.00	6.76	6.24
Jan. 1943			
Nov. 3, 1943	10.93	8.21	7.91
Apr. 1, 1945	12.43	9.71	8.98
May 22, 1946	14.28	11.56	10.83
July 1, 1947	15.48	12.76	12.03
July 1, 1948	16.48	13.76	13.03
Mar. 5, 1950	17.18	14.46	13.73

show reduction in costs over conventional mechanical mining costs to range from 25c to $1 per ton. Where size of final product is not important and where seam conditions permit the use of continuous mining machines, appreciable over-all cost reductions can be obtained. Where size is important and if important price differentials exist in favor of the coarser sizes of coal, the gain in lower costs may be more than offset by the decrease in selling price because continuously mined coal is smaller sized than conventionally mined coal.

The wage agreement adopted Mar. 5, 1950 increased the basic wages of mine workers $0.70 per day and increased the operators' contribution to the United Mine Workers of America welfare and retirement fund by 10c per ton of coal produced for use or sale. This put a heavy burden of increased costs on the operators in a period of tightening markets. However, belts were tightened, efficiencies increased with the consequence that these costs were largely absorbed without materially increasing the selling price of coal.

The coal mine worker is now the highest paid worker in the United States (see Table I). His daily earnings have increased three times or over since

Table II—Methods of Loading

	1940	1950
Mechanically Loaded Strip	9.4	23.0
Mechanically Loaded Underground	32.1	53.0
Hand Loaded Underground	58.5	24.0

1933, and if fringe benefits such as vacation pay and retirement are considered, the increase is more nearly four times. Despite this tremendous increase in labor costs, alert management has managed to keep costs from spiralling and prices have little more than doubled.

Strip mining continues to grow, largely because of economic forces favoring a small skilled labor force in combination with large units of machinery. Output per man-day at strip mines is estimated for 1950 to be approximately 15.7 tons. For underground mines it is estimated to be 5.5 tons. The relative changes in percentages of total production loaded at strip mines, mechanically loaded underground, and hand loaded underground since 1940 are given in Table II. The figures for 1940 are from U. S. Bureau of Mines sources, those for 1950 are estimated.

The year 1950 was one of the safest in the history of coal mining in the United States. Accidents on both an exposure basis and a severity basis were the lowest on record.

The growth in mine mechanization has created many problems in preparing coal for the market. This is illustrated by the fact that the average amount of refuse discarded at preparation plants in the early thirties was of the order of 5 pct, today it averages 15 pct for the country as a whole and there are many plants having refuse loads as high as 30 pct of the mined product.

Construction and new contracts slackened appreciably during the first six months of the year. Activity surged upward during the last six months so that at year's end major design and construction companies had a heavy backlog of orders.

Increasing stringent anti-stream pollution legislation in the major coal producing states caused considerable activity in the construction of water clarification systems and in slurry disposal systems. Wet plants built in the future must provide facilities to prevent contamination of streams.

Increased impurities in raw coal have added greatly to the complexity of modern plants. As compared to plants built a decade ago, with one or two cleaning circuits, the modern plant may have from three to seven circuits. A plant completed and placed in operation during 1950 had the following cleaning units: Picking table, Bradford breaker, Heavy-Media, coarse refuse re-wash jig, rheolaveur launders, concentrating tables, pyrite jig, and froth flotation—eight cleaning circuits. Obviously the problems of control and operation require trained men of a high order of specialization.

Cost of new washing plants cleaning all sizes, ranged from $3000 to $4000 per ton-hr of feed capacity during the year.

Sales of washing equipment in 1949 show the Baum jig in first place, sink-float units second, and launders in third place. Concentrating tables are being used increasingly for fine coal.

Approximately one third of the bituminous coal produced in the United States is mechanically cleaned. Table III gives the percent of each state's production mechanically cleaned. Practically all of the Pennsylvania anthracite production is mechanically cleaned.

Table III—Bituminous Coal Mechanically Cleaned in the United States, By States, 1949

(U. S. Bureau of Mines Sources)

State	Plants in Operation	Net Tons of Clean Coal	Output Mechanically Cleaned, Pct
Alabama	56	9,360,954	72.4
Alaska	2	190,384	43.9
Arkansas	3	55,491	5.8
Colorado	8	1,223,987	26.4
Illinois	62	27,426,245	58.1
Indiana	26	10,548,456	63.7
Kansas	5	1,101,022	54.2
Kentucky	52	12,894,543	20.6
Maryland	2	71,914	10.8
Missouri	9	3,004,757	82.4
Montana	2	182,411	6.6
New Mexico	2	339,672	33.8
Ohio	20	9,011,617	39.1
Oklahoma	5	738,718	24.4
Pennsylvania	78	31,964,239	35.9
Tennessee	4	193,884	4.6
Utah	5	2,086,754	33.9
Virginia	21	3,714,188	25.5
Washington	19	802,071	89.2
West Virginia	190	38,718,596	31.6
Total	571	153,651,903	35.1

South Africa's Premier Diamond Mines at Cullinan, now operating a 12,800 ton per day Heavy-Media Separation plant.

INDUSTRIAL MINERALS

have boom year in construction materials

BY RICHARD M. FOOSE

THE year 1950 has been a fascinating and unusual one as far as industrial minerals are concerned because of the sudden development of a critical international situation in late June. The first half of the year was marked by thriving peacetime conditions.

The high level of building and construction activity and industrial production brought new records to the entire industrial minerals industry. The unprecedented demand for such building materials as cement, gypsum, and perlite, resulted in the establishment of new records in production. The consumption of such industrial raw materials as sulphur, magnesite, salt, lime, phosphate rock and potash reflects the intense activity in nonmetallics and was at or near record levels. Many new mines and plants began operation and many producing plants expanded during the year.

With the development of the Korean situation, demand for nearly all nonmetallic minerals during the last half of 1950 rose so sharply that the mills were hard pressed to supply sufficient material to meet customers' requirements. The Defense Production Act of 1950 added greater impetus to the demand, since the Act calls for expansion in the production of all mineral raw materials essential to national defense. Naturally the wartime stimulus has regional aspects, and those regions closest to the concentration of heavy industry have received the greatest impetus.

The nation is on the threshold of wartime mobilization of manpower and industry; at the same time, inflation has not ended. Although credit controls and end-use limitations may relieve some shortages, the real impact of defense spending will not hit industrial raw materials until early 1951. It is likely that all the resourcefulness and latent flexibility of the vast industrial minerals industry will shortly be called upon.

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Abrasives—Demand for abrasives of all kinds, natural and artificial, was good during the year, with a marked increase in the latter part of the year undoubtedly stimulated by the beginning of industry gearing for wartime needs.

Corundum continues to be in greater demand than imports can satisfy. Artificial abrasives, like aluminum oxide and silicon carbide, have been produced at near capacity. Substitution of metal abrasives for sand abrasives during the past year was a sore spot with the sand industry.

Aggregates—Lightweight aggregates are in increased demand, particularly in the fine sizes such as used in wall plaster. Perlite has become the number one mineral in the making of plaster.

Acoustical tile is drawing more and more upon industrial minerals. Bloated plaster and bloated tile are coming into the picture. Indeed, almost nothing is escaping the experimental techniques of the lightweight aggregates people. Phosphatic slimes which may be obtained in large tonnages in Florida are receiving considerable attention for possible manufacture of lightweight aggregates and the same may be said for a wide variety of other minerals and materials.

Perlite continues to be the most rapidly growing industry within the field of lightweight aggregates. Typifying the rapid expansion of the industry is the great new plant constructed during 1950 at Socorro, N. Mex. by the Great Lakes Carbon Co. During 1949 there was much confusion surrounding the initial uses and development of perlite but during 1950 its place in the aggregates field became crystallized. Furnace designs, although still in a state of transition, have become more stabilized. In September 1950 a technical committee of the Perlite Institute

standardized specifications for use of perlite in plaster aggregate and are now working on other specifications for use in concrete aggregates. The obvious importance of this new material to the industry is evidenced by the fact that there are today 90 perlite miners and producers in the country.

An interesting new use for fly ash has been developed in the field of soil and road stabilization. A mixture of hydrated lime, limestone screenings, and fly ash have been used to make a road base for concrete and bituminous roads that in several instances has been demonstrated to be superior. Fly ash has also been used in great quantities in the construction of the Hungry Horse Dam in Montana.

Vermiculite has been in greater demand, and production was increased during 1950. Some vermiculite continues to come from South Africa. Blast furnace slag has proved to be just as effective as silica sand in some tests conducted for rock dusting. It is hoped this will prevent silicosis. Slag reduced to 12 to 16 mesh is being used for sanding tracks.

At Clearing, Ill., the Silbrico Corp. is operating what is probably the only slag brick factory in the United States. A slag brick is composed of 96 parts of water-granulated steel mill slag and four parts of high-calcium lime. Weight of these bricks is 4¾ lb and the color is light gray. For red and buff colored brick, pure iron oxide is introduced into the mix.

Asbestos—The most striking event in the asbestos industry in 1950 was the beginning of mining operations in a new deposit in Munro Township, 12 miles east of the town of Matheson, Ont. The deposit is about 325 miles northwest of Ottawa. It consists of irregular cross-fiber veins of chrysotile asbestos in serpentine similar to the well known deposits in Quebec. The fiber is mostly short to medium grades. Canadian Johns-Manville has had a quarry and mill in operation since April.

Research in asbestos synthesis is attaining increasing importance. The chief incentive is the scarcity of asbestos in the United States, particularly the grades of strategic importance such as long-fiber chrysotile of spinning grade, low-iron chrysotile found chiefly in Southern Rhodesia, and amosite mined exclusively in South Africa. The Bureau of Mines has undertaken a synthetic research project at Norris, Tenn., and work is also being conducted at the National Bureau of Standards, Rutgers University, Pennsylvania State College, and at other organizations. Considerable work has been done in Germany. Amphibole asbestos has been synthesized, but only extremely small fibers of chrysotile have been made. Research is being also devoted to substitutes for asbestos, and to beneficiating fibers unsuited for specialized uses in their natural state.

Barite—The United States continued as the world's largest producer of barite. The largest single use for barite was as an admix in well drilling muds. As more and more wells are drilled to greater average depths the demand for barite for this purpose increases. Although titanium dioxide is being substituted for lithopone to some extent, the shortage of titanium dioxide and a high demand for white pigments kept the use of barite in lithopone at a relatively high level. A considerable tonnage of barite was again imported from Nova Scotia. Shortages of barite and some barium compounds were reported in the latter part of the year.

Construction Materials—Production of cement in 1950 exceeded all records. Stocks toward the end of the year were about 30 pct less than 1949 having been critically depleted to meet the extraordinary demands. This unpredicted situation resulted in serious regional shortages that were aggravated by the coal strike, a shortage of railroad cars, and local labor problems.

The potential capacity of cement plants in 1950 was 260 million bbl. Many new plants were built during the year, and of real significance was the rehabilitation of a large number of old plants.

Most companies are quoting cement prices f.o.b. mill but one large company is not and there is national confusion on the ultimate effect and legality of the basing point system.

During the last five years fundamental studies dealing with clay mineralogy and basic properties have increased greatly. It seems likely that within the next five years knowledge of clays and their properties and potential uses will be increased a hundred fold.

Production and markets for dimension stone and slate increased slightly during 1950.

The unprecedented level of building activity during 1950 created a heavy demand for most gypsum products. The year was marked by continued expansion in the industry, both new and expanded plant capacity. Production of crude gypsum and of most gypsum products was at a record level. Crude gypsum mined during the year is estimated at about 8 million short tons; production of calcined gypsum at about 7,500,000 tons; imports at about 3 million tons. A general shortage of many gypsum products was reported during the latter part of the year.

The fact that supplies of sand and gravel are not inexhaustible is being realized in many parts of the country and exploration for new supplies has increased significantly. To help support this search the industry is actively seeking percentage depletion allowances. Experiment with impact crushing and renewed interest in sink-float methods are being directed toward the problem of removing deleterious particles, such as opaline silica which is largely responsible for alkali reactivity in concrete. Substitution of plastics for sand molds is a source of some limitation to that phase of the sand industry.

Diamonds—Renewed interest in diamond mining during 1950 has been pointed up by the request of the American Diamond Mining Corp. for permission to operate 20 acres of diamond-bearing alluvial ma-

The asbestos industry's biggest event in 1950 was the beginning, in April, of operations at the Johns-Manville Munro mine in Ontario. The site is 325 miles northwest of Ottawa.

terials in Arkansas immediately adjacent to two other well known properties that have been operated in the past.

During 1950 there was a tremendous increase in demand for industrial diamonds accentuated by the Korean situation beginning in June. Some of these needs may be met by domestic operations but, in the meantime, industrial diamonds for the Government stockpile are being mined in remote Africa under ECA contracts and the Marshall Plan.

The Premier Diamond mine in South Africa reached capacity production early in 1950 with its 12,800 ton per day Heavy-Media separation plant. Demand for diamonds toward the end of 1950 was approaching one million carats per month.

Feldspar and Pegmatite Minerals—Interest in recovering feldspar for flotation from pegmatite dikes continues. Whereas during World War II potash feldspar of high quality became extremely short, it would seem that with the flotation plants now in operation and those being considered for construction that no major shortage of this commodity will develop.

Publication of U. S. Geological Survey Professional Paper No. 225 makes available information on a series of tests that demonstrate the fact that much of our domestic sheet muscovite is equal in quality to the best grades of Indian material. Under critical wartime conditions we should be able to meet a large portion of demands for high grade sheet mica. However, present buying of strategic grade mica is largely in the Indian market.

As in the past, domestic production of sheet mica was only a small percentage of requirements and the bulk of supplies continued to be imported. Supplies of both muscovite and phlogopite splittings seemed to be adequate but block and film was in short supply. Several new firms were reported producing or anticipating production of scrap mica for grinding. Research on the synthesis of mica was progressing with projects at the Bureau of Mines Electrotechnical Laboratory at Norris, Tenn., the Bureau of Standards, Washington, D. C., and the Colorado School of Mines, Golden, Colo.

Considerable attention is being paid in several parts of the country to the production of spodumene and other lithium minerals which have become increasingly important with the possibility of renewed warfare on a global scale. This will be true not only from the standpoint of pigments and ceramics but also for their use as underwater propellents.

Large increases in the consumption of lithium minerals and compounds have been predicted for the glass and enamel industries and in lubricants. During 1950 most of the requirements for lithium minerals were satisfied by imports, mostly from Southwest Africa. However, reserves in the United States and Canada are believed to be relatively large and as soon as the domestic industry has had a chance to expand they can probably produce most or all of the requirements. Capacity has already been increased in the Black Hills district and new production is being considered in other areas. The spodumene deposit north of Winnipeg, Manitoba is being developed by Northern Chemicals, Ltd.

Beryl is in great demand and exploration for it and other beryllium minerals has been intensified during the past year.

Fluorspar—Increasing attention is being paid to foreign sources of fluorspar because increasing demands cannot be met from domestic reserves. Production continued at a high level throughout the year and increased in response to wartime stimulus toward the end of the year. The Kentucky-Illinois district produced four fifths of the domestic supplies.

Graphite—Domestic graphite is still in an unfavorable position. Foreign sources have stabilized somewhat during the year but are not yet completely satisfactory. Madagascar and Ceylon graphite are still highly prized and it is hoped to increase imports from these sources so that United States demands may be fully met.

The National Bureau of Standards, Washington, D. C., is making a comparison of domestic versus foreign flake graphites to determine their suitability for use in the manufacture of crucibles. The tests will cover such items as flake size, carbon content, toughness of flake, as well as thermal and chemical analyses. Other phases of the investigation include studies of bodies containing binders such as clay, tar, etc.

Limestone and Magnesium Minerals—The steel companies, the railroads, and independent capital geared to the expanding steel industry along the Atlantic seaboard have stimulated intense exploration for high calcium limestone deposits and high grade dolomites. Concurrently, the production of magnesite, brucite, sea-water magnesia, and dead-burned dolomite neared record highs.

Phosphate—There can be little doubt that fertilizers are increasing in importance. Most of the new plants are making elemental phosphorous. Victor Chemical Co. has constructed a new electric furnace for this purpose at Tarpon Springs, Fla., and are building another mill near Butte, Mont. Monsanto built its sixth furnace for this purpose during the past year at Columbia, Tenn. It is reported to be the largest in the world, using 25,000 kw. Westvaco is expanding their Pocatello, Idaho mill.

During the past year American Cyanamid Co. opened the Sydney mine in the phosphate field of Fla. International Minerals & Chemical Corp. purchased a site near Fort Worth, Texas, for construction of a 40,000 tons per year chemical fertilizer plant. The Gates Bros. plant at Wendell, Idaho, began manufacturing triple super phosphate.

One reason why potash deliveries reached an all-time high in 1950 was the U. S. Potash Co. refinery near Carlsbad, N. Mex., shown above.

Phosphate deposits near Lander, Wyo. are estimated to have a reserve of 20 million tons, and production is being planned.

Potash—Potash deliveries by the five major American potash producers and by three importers during the first six months of 1950 reached an all-time high. It represented an increase of more than 15 pct in potash salts and more than 20 pct in K_2O over 1949.

During the year there was considerable development work in New Mexico. Several companies were sinking shafts concurrently with exploration drilling. As a result, reserves of K_2O are now thought to be as much as 100 million tons.

The Potash Co. of America began construction of a $1 million plant to produce K_2SO_4 and HCl. Other items of general interest are that the radioactive properties of potash are being used in connection with new processing techniques and that one producer has developed a process of pelletizing potash salts to meet competition from free-flowing potash.

Quartz Crystal—During the first part of the year supplies seemed to be adequate but shortages were reported later in the year. However, it is believed that imports from Brazil can be increased. The most significant development in quartz crystal was the progress made in synthesis. A number of organizations were engaged in research and experimentation on the synthesis of quartz crystal. It is technically successful and production has advanced to small scale pilot-plant operation with the crystals produced going to research and testing.

Refractories—The industry is currently consuming about 15,000 tons of kyanite per year. Indian kyanite continues to be most in demand. A new foreign source is Kenya, but the material is not outstanding. It seems possible that current developments in the field of manufacturing mullite may ultimately displace all imports of kyanite. During the past year there were two domestic producers of kyanite, and sillimanite investigations were continued in the southeastern states.

There is a growing interest in the use of olivine in foundries as a refractory and as a substitute for silica sand. It has been reported that olivine can be used in places where dust is created and does not cause silicosis. Considerable quantities of olivine are being produced in Norway and some is being exported to the United States.

The use of low alumina silica for making superior duty silica brick is continuing in the refractories field.

Salines—Salt, soda ash, boron minerals, and other natural salines enjoyed a good year due to the high level of industrial activity.

Manufacture of soda ash, which is the biggest single use for sodium chloride, slumped badly because of strikes at seven soda ash plants during the year. However, the manufacture of chlorine, which is the second largest use for sodium chloride salt, increased from the beginning of 1950 and probably will set a new record by year's end.

Producers of borax have developed the production of sodium borate pentahydrate which competes with concentrated and calcined borate ores. Producers are increasing the supplies of dehydrated borax.

Sulphur—It is estimated that reserves of salt dome sulphur might last for 30 years. The current exploration programs of the two major sulphur companies have apparently not succeeded in adding any significant tonnages. It would appear, therefore, that new sources of supply must be sought from different geologic environments.

Perhaps the biggest potential new source of sulphur in the country will be the extraction of sulphur from sour natural gases. The process for doing this was proved successful during the past year at several places, including two plants in Wyoming. It seems likely that additional plants will be constructed for sulphur extraction from gases in many parts of the country.

The Continental Sulphur & Phosphate Corp. has been formed to develop and mine sulphur near Cody, Wyo. Sulphur reserves are estimated to be sufficient for 30 years supplies at a 200 ton per day rate.

Talc and Pyrophyllite—Despite the fact that total production capacity of New York State talc is now 50 pct greater than during World War II, from June on the demand for talc increased so sharply that by early December the situation on many grades of talc was even more stringent than at any time during World War II. The outstanding quality of North Carolina talc also has made it in short supply. During 1950, Montana talc deposits developed rapidly and are moving into a prominent position in the market because of their quality. California mines are not maintaining their share of the market because of difficulties in mining in remote areas and lack of mill capacity.

Importation of high quality Indian talc was resumed during the latter part of 1950 to meet certain quality needs of customers.

Pyrophyllite consumption during 1950 increased sharply during the latter part of the year so that all mills were pressed to supply customer demands. Insecticide grades of pyrophyllite were in special demand during the late spring and summer months of 1950.

African Wonderstone is closely related to pyrophyllite. Research with this material during 1950 demonstrated that it has excellent dielectric properties and an extremely low coefficient of expansion which makes it resistant to thermal shocks. It would be an increasingly important industrial mineral.

Other Minerals—India continued to embargo shipments of monazite sands during the past year and is reported to be building a plant to process them and sell the rare-earth compounds. During the year Brazil, the other principal source, restricted and finally embargoed shipments, leaving the United States without an important source, although there is considerable activity in some of the stream placers of central Idaho.

Possibly a substitute source of the rare earths may be the new mineral bastnasite discovered in 1949 by two prospectors near Mountain Pass in San Bernardino County, Calif. The property has been purchased by Molybdenum Corp. of America and is now being developed. The mineral is a lanthanum and cerium-rich fluocarbonate.

Although optical calcite (or Iceland Spar) is used only in small quantities, shortages were reported during the year. This probably was caused by improper care in mining, preparing, and packing these delicate crystals.

During the last year several hundred tons of wollastonite were produced near Willsboro, N. Y., by the Willsboro Mining Co. from a deposit owned by Northern Minerals, Inc. of Essex, N. Y. Production went to the ceramic, refractories, and welding industries. Research continues on its utility in the paper, chemical, rubber, and paint industries.

MINE SAFETY MAKES PROGRESS

lowest fatal injury rate in history
conferences stress selling worker on safety
international safety conference beneficial

by S. H. Ash

DEMAND for industrial minerals has focused attention of mining people on means for preventing absenteeism of workmen, prevention of disease, and conservation of labor in the mineral industry. Health of workers is necessary for efficiency and favorable public relations. Some states are emphasizing the need for state-wide surveys that may uncover health problems in industry that will need further detailed study.

Means for conserving health continue to concern environmental health hazards, with particular emphasis on dust. Mechanical appliances for mining and transporting large tonnages are becoming increasingly numerous; these create considerable dust that should be suppressed at its source. Some coal mining companies are becoming more active in attacking the dust problem as it relates to health. An important primary weapon in the fight against the effects of dust is ample ventilation; without it, a partial to complete nullification of otherwise efficient dust control measures will result. Dust control measures are designed for both prevention and suppression of dust.

Numerous mine safety conferences were held in widely separated places during the year and attendance at these meetings was the largest to date. Mining men from the production line could well afford to attend the conferences held by the Lake Superior Mines Safety Council, Coal Mine Inspectors' Institute of America, AIME, American Mining Congress, and National Safety Congress.

It is apparent that the worker is the focal point in preventing accidents on the production line. Favorable response to the change in the subject matter of papers presented at safety conferences is noticeable. Present-day papers cover in more detail importance and method of job training supervisors and workers, methods of working, and descriptions of processes. The relationship between how to do a job, how a job is done, and how it should have been done is explained. Attendance of younger men is increasing and is evidence of widespread interest in accident prevention.

Safety education of the worker and his immediate supervisor is fundamental for preventing accidents. The desirable practice of first-aid training long has been recognized as the simplest, surest, and most efficient method of focusing the attention of management, labor, and the public on what injuries mean and that the problem of preventing them is a mutual problem of management and labor. How best to renew and stimulate interest in this method of preventing accidents is paramount. A National First-Aid Contest was held at Pittsburgh, on Oct. 21, 1950. Sixteen teams participated, representing Kentucky, West Virginia, Ohio, and Pennsylvania. This contest was sponsored by the National Coal Assn. and the chiefs of the Departments of Mines of the states were represented.

The organization and work of the Montana Safety Council, in which the mineral industry is important, is a forward step in promoting safety. This organization took a leading part in the proceedings of the second annual Governor's Safety Conference held in

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Table I—Fatal Injury Rates for the Mineral Industry and Its Branches (Except Petroleum)—1931 to 1949, Inclusive.

	Fatal Injuries per Million Man-Hr						
Year	Bituminous Coal Mines	Anthracite Mines	All Coal Mines	Metal Mines	Metallurgical Plants	Quarries	Mineral Industry
1931	1.60	1.84	1.66	1.06	0.23	0.48	1.33
1932	1.77	1.59	1.73	1.25	0.18	0.34	1.43
1933	1.31	1.49	1.34	1.09	0.28	0.67	1.17
1934	1.41	1.50	1.45	1.07	0.22	0.63	1.22
1935	1.46	1.78	1.52	1.02	0.33	0.48	1.23
1936	1.43	1.58	1.48	1.08	0.32	0.62	1.18
1937	1.54	1.58	1.55	0.94	0.35	0.48	1.19
1938	1.52	1.94	1.59	0.88	0.22	0.61	1.20
1939	1.36	1.71	1.42	0.86	0.25	0.53	1.07
1940	1.68	1.80	1.65	0.99	0.16	0.49	1.24
1941	1.35	1.49	1.37	0.92	0.28	0.44	1.05
1942	1.41	1.64	1.44	0.96	0.31	0.62	1.13
1943	1.39	1.50	1.40	0.94	0.18	0.52	1.08
1944	1.23	1.06	1.20	0.80	0.23	0.56	0.97
1945	1.13	1.01	1.11	0.68	0.16	0.42	0.88
1946	1.09	1.14	1.10	0.69	0.20	0.35	0.86
1947	1.23	1.18	1.22	0.80	0.17	0.44	0.94
1948	1.15	0.91	1.11	0.84	0.13	0.42	0.84
1949	0.93	0.85	0.91	0.51	0.21	0.37	0.66
Decrease from 1931 to 1949, pct	42.5	53.1	45.2	81.9	8.7	24.3	50.3

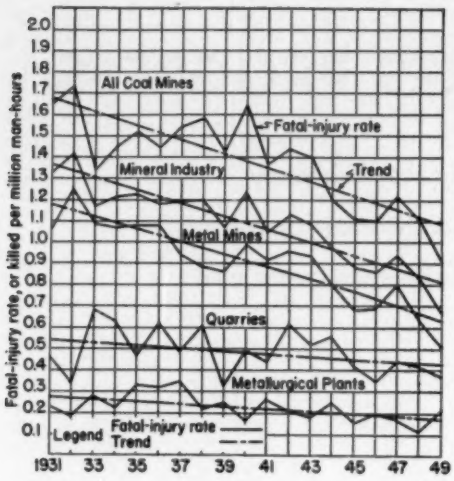


Fig. 1—Fatal-injury rates and trends for mineral industry and its branches, 1931-49.

Helena, Mont., Oct. 6 to 7, 1950. Favorable public relations result from improved injury experience.

The second session of the President's Conference on Industrial Safety was held on June 5 to 7. The keynote of the deliberations of the conference is to increase the effectiveness of industrial safety programs. These conferences have unquestionably resulted in the development of governor's conferences on industrial safety in several states. The absence of aggressive participation by either representation or discussion on the part of the mining industry at the President's conference was conspicuous. What industry should be more vitally concerned with public opinion regarding its safety record than the mining industry?

The mining industry should take a leading part in the President's and the governors' conferences on industrial safety. Some of these conferences are held where the mineral industry is particularly active, in California, Montana, Illinois, Tennessee, etc.

The mining industry made a prominent contribution to international mining safety studies by presenting papers and large attendance at the Sixth International Conference of Directors of Mine-Safety Research at Paris, July 24 to 29, 1950. Representatives of management, labor, and government participated in the program, which was acclaimed the most successful of its kind. Diplomats disagree more often than not on international problems, but no disagreement exists among men throughout the world on the prevention of accidents from mining processes. The diversity of branches of the mineral industry makes coordination of accident-prevention efforts difficult. However, such coordination is imperative if favorable public relations and unity within the industry are to be maintained.

Research

Research, both development and applied, in mining equipment and methods has proved to be a strong public-relations asset. Environmental hazards have been reduced, but study of unsolved problems is desirable. These cover a wide field, including: Improved illumination at the working face; improved durability and accuracy of gas-detecting instruments; prevention of misfires in electrical blasting; development of fire-resistant trailing cables; simpler and more reliable methods of cutting off electric power and thereby reducing fire hazards; development of emergency underground communication methods and instruments; safer and more efficient blasting; and a simple and economical method of removing aldehydes from Diesel-engine exhaust gas.

Progress in the acceptance of roof bolting in coal mines particularly, is an outstanding achievement in mining safety. More than 450 mining companies, of which 350 are major bituminous-coal producers, are using roof bolts to support 90 million sq ft of roof surface. Bureau of Mines Information Circulars 7533 and 7583 and two films, *Roof Bolting in Ore Mines and Roof Bolting in Coal Mines*, describe this method of supporting mine roofs.

A more widespread use of roof bolting will prevent many injuries from falls of roof, which cause half of the deaths and most of the nonfatal injuries in mining. Drilling holes for roof bolts releases gas and water, which relieves pressure on critical strata forming the immediate roof.

Although roof bolting originated and has been used in some metal mines for years, this branch of the mineral industry is manifesting renewed interest. The requests for information have become world wide. The progress made in developing and adapting roof bolting for roof support in all types of underground mines during the past two years, particularly in mechanized mines (coal and metal), is remarkable.

The widespread utilization of roof bolting in both coal and metal mining is causing an increasing demand for mobile air compressors. Many coal mines had no use for compressed air until they started drilling holes for roof bolts. Some large coal mining companies are installing large central compressors

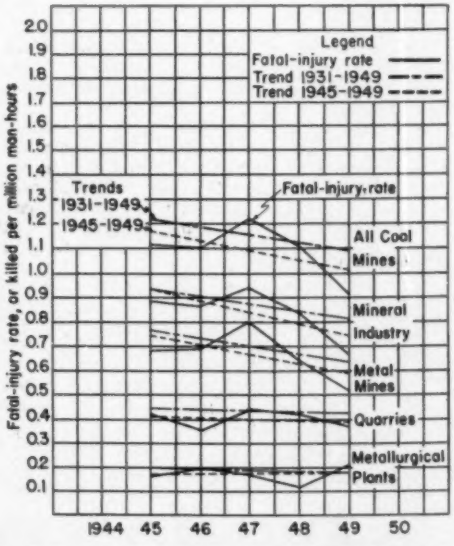


Fig. 2—Fatal-injury rates and trends for mineral industry and its branches, 1945-49, with 1931-49 trends for comparison.

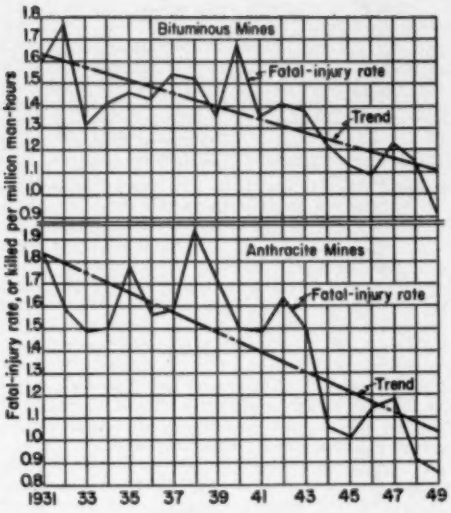


Fig. 3—Fatal-injury rates and trends for bituminous-coal mines and for anthracite mines, 1931-49.

instead of mobile compressors and find them more economical. Compressed air makes it possible to use a portable air-driven rock duster at the face as it progresses. Most dust explosions originate near the face. This equipment is used in some deep coal mines in Washington. Many new uses will be found for compressed air now that it is becoming available in coal mines.

Injury Rates

Statistics alone never win popular support for a cause, but an accident prevention program without them is like a mine without a cost sheet. The cost of accidents, as measured in both injuries and dollars, follows the trend of fatal injury rates.

Table I and Figs. 1 to 4 show that safety has improved in all branches, more so than at any time since injury statistics have been compiled.

Percentage-wise, the greatest improvement in the fatal injury rate since 1931 is in anthracite mining, followed by metal mining. It appears that fatal injury rates are controlled to a large degree by factors within the industry that may be considered by some as inherent and that account, under present-day conditions, for a fatal injury rate of 0.2 deaths per million man-hr—a mark to shoot at. When this mark is reached, and it can be, a further reduction can be made. The mineral industry has halved its fatal injury rate since 1931.

An outstanding accomplishment in coal mining safety is that a major disaster has not occurred since Nov. 4, 1948.

The best fatal injury rate in the bituminous coal industry was achieved in 1949, when 500 fatalities occurred and the fatal injury rate was 0.92. The rate for the first 10 months of 1950 is 0.91, and it is doubtful now that the 1949 rate will be bettered in 1950.

The anthracite industry, however, presents a different picture. The best annual fatal injury rate in both the anthracite mines and the entire coal-mining industry was attained by this branch in 1949, when 93 fatalities occurred and the fatal injury rate was 0.85. Anticipating 80 fatalities for 1950, it appears that the 1950 fatal injury rate may mark a new low of 0.63. The fatal injury rate for the 11-month period January to November was 0.67, 16 pct better than the best 11-month period in the history of anthracite mining.

In general, the condition of the coal mines in the United States, from the standpoint of health and safety, is better today than at any other time in the history of the industry.

A mine fire at the Lark mine in Utah on July 16, 1950, killed five persons. The fire probably was caused by some electrical failure. This was the first major disaster in metal mining since February 1943. The author pays tribute to those workers and officials who fought the Lark mine fire and conducted recovery operations under arduous and hazardous circumstances.

Despite the lessons learned from mine fires, they are still occurring from the same causes. A description of means and methods for controlling and extinguishing them is always of interest at safety or technical meetings.

Because mine fires are a major disaster hazard in metal mines, the industry can well afford to take stock, review the causes of mine fires, and do something about preventing them in those places where the hazard is evident. Controlled ventilation, fire doors to sectionalize mines, and alerted fire-prevention techniques are recommended, not only to prevent destruction of lives and property if a fire inadvertently occurs, but also to be prepared to act promptly in the event of a fire caused by sabotage or subversive activity, which by no means can be rejected as impossible. All persons at every mine should know the dangers from mine fires as well as know what to do and what not to do in the event of fire.

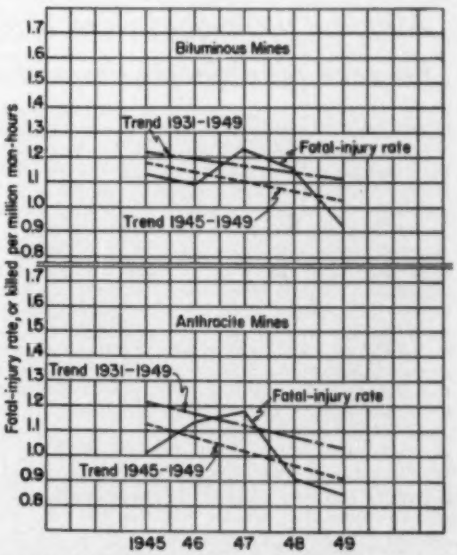


Fig. 4—Fatal-injury rates and trends for bituminous-coal mines and for anthracite mines, 1945-49, with 1931-49 trends for comparison.

"Let's Start Digging Here. It looks like as good a place as any." By permission. Copr. 1950 The New Yorker Magazine, Inc.

GEOPHYSICS

by Sherwin F. Kelly

Airborne techniques enter hard rock exploration field . . . the gap between pure geophysics and engineering seen as closing rapidly.

EFFORTS of early geophysicists to learn the physical constants of our globe gave rise to most of the geophysical techniques used in exploration. Subsequently, the preoccupation of exploration geophysicists with the relatively minute anomalies caused by mineral deposits resulted in a divergence between the path of exploration geophysics and that of global geophysics. Those paths are today rapidly converging. The increasing overlap between these hitherto somewhat distinctive disciplines, results from the growing concern of exploration geophysicists and geologists with the setting of ore deposits in the larger tectonic picture. In addition interest of the global geophysicists is increasing in the more detailed study of those variations in physical constants of the earth which are indicative of some of its major and minor structural features. This is symptomatic of the broadening outlook of both geologists and geophysicists. It is also symptomatic of recognition that broader research will yield significant data concerning the bearing of tectonic features on metallogenetic areas and eras, and about the phenomena that control broadly the loci of mineral deposition. The artificial distinction between *pure* and *applied* geophysics is thus rapidly disappearing.

MR. KELLY is Secretary, Geophysics Subdivision, AIME, and also Chairman, Geophysics Subdivision, CIM.

Significant research was reported by George Woollard, Maurice Ewing and Henry Joesting. A global gravity network, established under the Office of Naval Research, was extended this past year by numerous observations in the Pacific, Orient, Alaska, Atlantic, Africa, and Europe. A 5500 milligal range, temperature-compensated Worden gravimeter was specially developed for this task. It is a project which, in addition to providing valuable geodetic data, will also furnish a framework of broad gravity variations into which may be fitted the regional anomalies of more direct, geological interest. Studies on the regional scale included preliminary work on a series of precise, pendulum gravity base stations over a considerable range of longitude in North America. In addition, gravity and magnetic traverses, with stations at 10-mile intervals, from Wisconsin to the Pacific, and up the Alcan Highway into Alaska, were sponsored by the Geological Society of

America and the Research Directorate of the U. S. Air Force. The U. S. Geological Survey conducted several aeromagnetic traverses across the continent, off the California coast, and over the continental shelf from Newfoundland to the West Indies. The same type of survey was also applied in Oregon, Montana, and New Jersey to obtain general geologic information. Such projects as these form the prototype of the research required to provide, in turn, the framework of regional gravitational and magnetic data into which may be fitted those yet smaller geophysical anomalies which are the objectives of the exploration geophysicists.

The dividing line between regional and local studies is hard to define, when the airborne magnetometer covers such wide areas so rapidly. In petroleum geophysics particularly, the procedure takes on most clearly the aspect of regional research. This is especially true of the new oil fields in Canada, where Aeromagnetic Surveys Ltd. is reported by H. S. Scott to have flown 33,000 sq mi in Alberta and Saskatchewan in exploration for oil. In addition, this firm extended its Edmonton-Toronto aeromagnetic profile, east to St. John's, Newfoundland. Also, it flew about 7000 sq mi in the exploration for asbestos and for base metals, including iron in Ontario, Quebec, and Newfoundland.

The USGS flew some 25,000 miles of aeromagnetic traverses making studies of the Wisconsin lead-zinc area, the lead and iron district of southeast Missouri, a potential bauxite area near Little Rock, Ark., oil districts in Louisiana and California, and manganese deposits in Maine. The last-named survey was supplemented by ground traverses. An aeromagnetic survey of Minnesota's iron districts revealed a southeastern extension of the Vermilion range, and some other promising areas now being drilled. Airborne radiation surveys were flown in Michigan, Utah, Wyoming, and South Dakota, for a total of over 10,000 miles. Airborne scintillometer research was also carried out in Canada by Aeromagnetic Surveys Ltd., which found reproducible results.

The invasion of the aeromagnetic and other airborne techniques into the field of hard rock exploration, is broadening the scope of mining geophysics, and bringing its practitioners closer to the oil geophysicists.

This is but one facet, however, of the increasing interdependence between mining, oil, civil engineering and pure geophysical practices, which also extends to surface and subsurface techniques. George Woollard reported that local gravity and magnetic surveys were carried out in connection with petrologic basic fronts in Wisconsin, to map buried preglacial surfaces. L. Loyal Bacon has been making subsurface gravity measurements in mines, with some success, and is currently engaged on a gravity survey of the iron country. H. R. Joesting wrote that the USGS has established a net of magnetic stations on the Hawaiian Islands in an attempt to find a possible relation between changes in the magnetic field and volcanic activity. In the Aleutians, tiltmeters and seismic equipment have been installed to see if eruptions can be predicted. Engineering projects in Alaska are benefiting from permafrost investigations in drill holes by geothermal observations. The studies of hydrothermal alteration zones at Steamboat Springs by geothermal, electrical, and magnetic measurements, reported last year, are said to be successful in tracing such zones as a part of research on ore deposition processes.

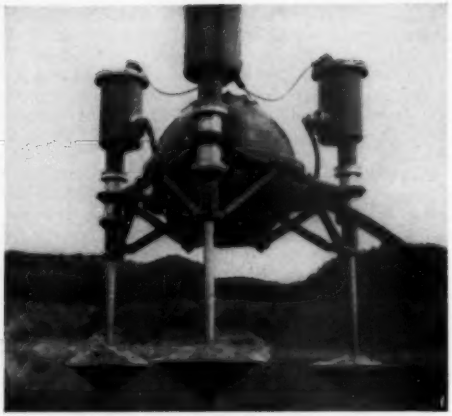
In the field of geothermics, C. R. Van Orstrand reported studies on permafrost in Canada by J. L. Jenness, investigations of changes in gradient in South Africa by D. J. Simpson and F. R. Bouwer, the relationship of uplift and denudation to temperature gradients, and a progress report on thermal and radioactive studies in the Canadian Shield by A. D. Misener.

From Washington University, LeRoy Scharon sent information that electrical resistivity methods are being applied with some success in the Tri-State district and with highly successful results in the study of bedrock depths on the eastern and western extensions of the Pennsylvania Turnpike. Combined with magnetic methods, excellent results are being obtained in the Fredericktown lead district of Southeast Missouri. M. M. Leighton reported that the Illinois Geological Survey is engaged in research on geologic aspects of radio wave transmission. Results to date indicate that some geological structures influence the behavior of radio fields, and investigation of such phenomena might influence the locations of radio transmitters, as well as serve as a useful exploration technique.

Both electrical resistivity and seismic refraction methods were utilized in Wisconsin, according to George Woollard, to study gravel prospects and ground water supplies. In the Midwest, the USGS employed electrical measurements in the search for ground water, and in Massachusetts, used seismic methods on highway engineering problems. Seismic experiments on floating ice sheets, and seismic refraction profiles across the buried Hudson River gorge, have been carried on by Maurice Ewing. The N. Y. State Science Service is reported by Philip Donnerstag to be engaged in resistivity work on the solution of ground water problems, and in ground magnetic studies to check airborne, magnetic highs in the Adirondacks.

From Pennsylvania State College dept. of earth science, B. F. Howell, Jr. reported experiments in well logging which demonstrate that the formation resistivity factor depends on the nature and concentration of the solution filling the rock pores, and probably also on the composition of the rock. Gravitational anomalies in Pennsylvania are being studied,

During the year, Heiland Research Corp. brought out this oscillograph recorder for seismic work. It incorporates recording camera and oscillograph, features readily accessible cathodes.



Underwater gravity surveys at Steep Rock Lake in Canada were done with this underwater gravimeter, using remote control and reading.

and a gravity map of the state is under preparation. Research, supported by the Office of Naval Research, is in progress to study the nature of seismic waves from explosions and the manner of their transmission through such nonelastic media as loose earth. Studies are also under way on the theoretical limits of airborne, radioactivity prospecting.

In Canada, Hans Lundberg is likewise experimenting on airborne recording of radioactivity over ore zones and oil fields. Preliminary results indicate the possibility of determining the presence or absence of oil or gas. The most extensive part of his company's program has been concerned, however, with testing its airborne magnetic and electromagnetic equipment on oil structures in Saskatchewan, Alberta, and the Gaspé, and on ore-bearing zones in Sudbury and Noranda, with successful results reported. Information on the activities of Koulomzine, Geoffroy & Co. indicated that most of their field work was by magnetic methods, but electrical, electromagnetic and radioactive techniques were also employed, and drill hole surveys were carried out. Instrumental research and theoretical studies were pursued to improve equipment for drill hole studies and interpretive techniques. Underwater gravity surveys at Steep Rock Lake have been under the direction of G. R. Johnson of Radar Exploration, to study the possibilities of discovering additional iron ore. The instrument employed was a LaCoste and Romberg underwater gravity meter utilizing remote control, remote reading, and equipped with an integrating device. Operating from a raft made of 24-in. pipe, about 500 stations could be occupied per month. The Sherritt Gordon Mines geophysical program, reported by R. W. Drybrough, was somewhat reduced this past year, although a total expenditure of about $30,000 was made for surveys.

There are well-substantiated rumors emanating from Canada that an aeromagnetic high in eastern Ontario has recently been drilled, with the resultant discovery of a tremendous body of magnetite ore said to be 2200 ft long and 400 ft wide, within a few hundred yards of a railroad. This discovery was made where the Pre-Cambrian is covered by a few hundred feet of later sediments. It thus opens up tremendous possibilities for exploration in the sedimentary areas of southern Ontario. Another, similar report relates the discovery, again aeromagnetically, of nickeliferous pyrrhotite beneath continuous overburden, in an area south of Timmins.

Aero Service Corp. reports, via Homer Jensen, that they have been conducting aeromagnetic surveys during the past year for magnetite, hematite, and asbestos. This has included, among others, surveys in Ontario and Venezuela. In the latter country a test was made for the effectiveness of the technique on a particular survey problem on the great Cerro Bolivar iron discovery. Geophysical Explorations Ltd. of Canada, and Sherwin F. Kelly Geophysical Services, Inc. of the U. S., both under the direction of your reporter, have been making dam site surveys in the U. S. and Canada, studies of gravel deposits in British Columbia, and electrical resistivity and spontaneous polarization surveys on base metal deposits in western Canada, Ontario and Quebec. William Callahan of New Jersey Zinc Exploration Co., wrote that they have continued their reconnaissance and detail surveys, using electrical inductive, magnetic, and gravitational methods, on some 20 sq mi of territory in northwest Quebec. Drilling begun late in the season has already disclosed both massive sulphides and graphitic material. The Geolectric Exploration Co. Inc. (Schlumberger-Doll processes) is reported by E. G. Leonardon to have developed an inductive prospecting device, using a low frequency field, which is light enough to be operated while walking. Wm. M. Barret, whose Radoil method of detecting oil pools was reported last year, has brought out a similar technique, Radore, also utilizing radio waves for detecting metallic ores.

The USGS is continuing research on developing suitable and rapid methods of chemical analysis, according to H. Hawkes, aimed at gaining better understanding of the distribution of metals in the vicinity of buried mineral deposits. Rapid tests for nickel and copper were published, and reports are being prepared on cobalt, molybdenum, tungsten, and silver. Field work was conducted on lead-zinc districts in Idaho and Wisconsin, and shorter investigations made in Arizona, California, Utah, Virginia, and North Carolina.

L. Don Leet of Harvard, reported continued research on vibration phenomena, and that seismology is playing an important role in strip mining and quarrying operations. Especially important have been measurement and analysis of vibrations from blasting to study effects on structures, and to investigate the efficiency of the new short-period delay detonating systems. The short-period delay shooting reduces vibrations, but just how, is not yet clear. A curious phenomenon in this connection is that the ground vibration is actually less when the number of shots fired exceeds a critical minimum of about five to seven holes. Thus, a charge of 37,000 lb causes less vibration than one of 12,000 lb, and the latter in turn, produces only half the displacement caused by firing that same amount instantaneously. A 3-component, ink-writing seismograph was developed at Harvard by R. K. Blumberg, which can be operated continuously if needed, and used to monitor commercial blasting as much as 50 miles away.

A few reports were received from abroad but these scattered data probably do not give a true picture of the scope of geophysical activities in foreign fields. From Calcutta, Ramachandra Rao re-

ports continued research and field work by the Geological Survey of India, with which the Geophysical Section of the Mysore geological dept. has now been integrated. Magnetic surveys to study manganese deposits in the Central Provinces have resulted in the discovery of some ore bodies. In Nellore district of Madras magnetic, spontaneous polarization and resistivity surveys were used near some old copper workings, to check electromagnetic inductive anomalies of a German survey in 1933. No indications of sulphides were obtained, and the inductive reactions were found to correspond to bodies of wet clay. Resistivity determinations, both from the surface and in wells, were made in the saline tract of Rajasthan to demarcate zones of highly saline ground water, in connection with plans for salt manufacture. Bedrock studies were conducted, utilizing the resistivity technique, at proposed dam sites in Madras and Bombay. The Geodetic Branch of the Survey of India is making progress in the gravimetric and magnetic studies it is pursuing, and has recorded some anomalies which may prove to be of importance, near Raniganj, one of the most important coal fields of India.

A number of surveys in connection with engineering and water supply problems were carried out by Geophysical Services Ltd. of London according to J. Robertshaw. These included resistivity surveys to map bedrock profiles for hydroelectric projects on the Navua River, Fiji Island, in the Kariba Gorge of the Zambesi River in Southern Rhodesia and on the Volta River in the Gold Coast. Some of this work required the use of floating electrodes, or electrodes suspended from ropes spanning the gorge, or operating from boats. One of their surveys, in Scotland, employed resistivity traverses along the route of a proposed 40-mile water supply pipe line to determine bedrock depths, in order to estimate the rock excavation which would be required.

The Geophysical Prospecting Co. Ltd. of London, which has acquired control of the Geotechnical Development Co. Ltd. of Canada, reported through J. T. Randell that there is a marked increase in geophysical surveys for civil engineering projects, particularly for water supplies, not only in England, but throughout the world, and also increasing interest in the use of geophysics for investigating structures relating to coal. In the base metal field, the companies named have been active in the Chibougamau field of Quebec, where three new bodies were found which are now being drilled. A new resistivity technique was employed which permits winter operation with electrodes merely in contact with the ice.

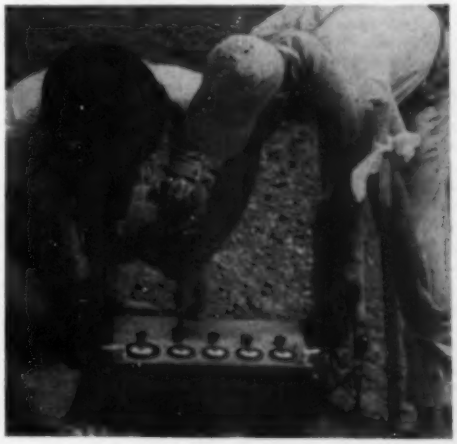
The director of the Geological Survey of Southern Rhodesia, J. C. Ferguson, sent the interesting information that the electrical resistivity method has been regularly used since 1935 by the irrigation dept. of that Colony, in the development of water supplies. The percentage of successes has been about 80 pct.

The Commonwealth of Australia also ranks as a country which has long appreciated the value of geophysical exploration, dating back to Broughton Edge's work there is 1928-30. J. M. Rayner, chief geophysicist for the Ministry of National Development reported extensive geophysical surveys covering a wide range of problems. Work on metalliferous deposits accounted for a large share of attention, comprising magnetic, electrical, gravity, seismic and radioactive techniques. Stratigraphic studies for oil and gas, coal and water were nearly as important, followed by engineering investigations. The absolute gravity and magnetic surveys of Australia, New Guinea, etc. were continued, and geophysical observatories were operated to carry out magnetic, seismic, earth current and ionosphere investigations in Australia, New Guinea, and the Sub-Antarctic. The structure of the Barrier Reef was also under geophysical investigation, and laboratory research and development were pursued. It is stated they are aiming at building up a staff of about 100 geophysicists.

There have been numerous advances in oil geophysics. M. K. Hubbert called attention to the *miniaturization* of seismic equipment, as manufacturers continue to make the sets smaller and more compact. He also stated that a significant, new advance is the Pasley cable, developed by L. C. Pasley, of the Marine Instrument Co., who imbeds a large number of seismometers within a 2½-in. cable. The density of the cable is made equal to that of sea water, so it remains suspended in the water when towed. Records are made by slowing the boat as the shots are fired, thus materially speeding up off shore seismic operations. Continued progress is being achieved in the applications of the air-shooting technique, introduced by T. C. Poulter of Stanford Research Institute. He wrote that a considerable amount of seismic work was carried out in the Edwards Plateau area of Texas, in a region which heretofore was not considered amenable to reflection work. Shooting lines only a mile or two long was found not too significant, so a plan was adopted of shooting a minimum of 20 miles of continuous profiles. Satisfactory results were obtained in this program, even in Crockett and Sutton Counties in rough terrain, where the survey lines followed section lines rather than being confined to favorable terrain. The objective of this research is to achieve a better control of the energy introduced into the ground, from which to obtain seismic records.

According to the analyses of L. Don Leet, long seismic profiles demonstrate that the laws of geometric optics fail to predict correctly the earth waves that will be recorded from a given structure,

Radare transmitting equipment, showing radiator (left) and ground connection at right.



if the layers are not sufficiently thick to carry recordable energy to distant points. Sand lenses are commonly of such small dimensions as normally to be indefinable by usual seismic procedures, but A. J. Barthelmes of Seismograph Service Corp. reported a procedure for mapping these structures seismically. Briefly, differential compaction of the surrounding and overlying shales produces a slight upward bulge, possibly 20 ft, in the overlying horizon. The low velocity of transmission through a fluid-filled sand lens results in recording a false time syncline immediately below the sand bar. By utilizing a sufficiently close control, it is possible he stated, to discover such small, up and down bulges, and thus to map sand lenses.

The Schlumberger Well Surveying Corp. has introduced a new method of electrical logging, described as the Microlog. A small electrode system is used, with the electrodes applied to the wall of the drill hole. The method provides a detailed record of the formations traversed, and makes possible the location of permeable zones within compact formations, and the determination of the amount of sand in sequences of thin shale and sand streaks. The related Paris firm, Compagnie Generale de Geophysique is reported by E. G. Leonardon to be carrying on a large amount of oil exploration work utilizing telluric currents, in addition to the more traditional techniques. The telluric current method is being applied in France, Italy, North Africa, Gabon, Madagascar, and Assam, and to date has covered some 9000 sq km. The Schlumberger Well Surveying Corp. is currently applying this technique for oil exploration in Venezuela.

Important data on the scope of geophysical exploration for oil came from C. A. Heiland, D. C. Skeels, W. H. Courtier, A. F. Beck, R. A. Walters and C. B. Bazzoni, and is combined in the following notes.

The tremendous increase in seismic activity in Canada is one of the outstanding developments of the year. As of Nov. 1, 1950, there were 104 seismograph, 10 gravity and 3 magnetic (2 airborne) parties operating in western Canada. Most of the activity was in Alberta, followed in order by Saskatchewan and Manitoba. Eleven new oil pools and 15 new gas pools discovered in Alberta in the first 10 months of 1950 demonstrate the ability of the refinements in the seismic technique to find limestone reefs of low relief. The extension of seismic surveys into the Canadian north country has required innovations in portability of instruments and in means of transportation. Winterizing of the equipment has made it possible to operate in temperatures as low as −60°F. In the summer, soft muskeg has necessitated the use of weasels, broadtrack caterpillars, bombardier trailers, and horses for the transportation of men and equipment. Under these conditions, portable or semiportable recorders are required, providing a potent spur to further *miniaturization* of instruments. For transporting gravity meters, helicopters have been called in and at least one airborne magnetic survey, in the Peace River area, was conducted as a joint operation by a group of companies.

The problems presented by reef shooting in Alberta, and by high inclination structure shooting in the Rocky Mountains, have demanded some deviation from standard seismic practices. Combinations of refraction and reflection shooting are often employed, and greater attention is being given to the determination of velocities in the ground. Airborne magnetic results are of value in determining the type of basement folding present, if any, and in yielding knowledge of the thicknesses of the sedimentary sections.

Seismic activity in the U. S., low at the beginning of the year, is on the increase, and some 590 crews are reported in the field. Gravity crews number roughly 75, and magnetic ones 25, with three crews credited to resistivity, soil analysis and Radoil. Texas accounts for the largest amount of activity, followed by Wyoming, Louisiana, Nebraska, and Colorado, in that order. Nearly 100 seismic crews are operating in West Texas, where a reef play of significance is in progress. The technique of reef exploration relies on mapping the time interval between reflections from above and below a reef horizon, a minimum interval often indicating a velocity anomaly due to reef material.

Off shore deep water shooting has declined compared to last year. A small number of crews is operating, in the Gulf coast region, covering the area so fast that virtual completion of this stage of exploration may be expected in the near future, at least on the reconnaissance scale. Lake Maracaibo in Venezuela, hitherto closed to seismic work, is now being explored by that method. It is in some respects a joint operation, as a single contractor is carrying it on, under seasonal restrictions imposed by the government. The technique employed utilizes geophones mounted in a cable, previously described, with the shot at the end of a cable payed out from the same towing boat. The operation is practically continuous, and a speed of 450 miles of line per month was reported.

Geophysical activity in South America was at a low level this past year. In Venezuela there were 27 seismic crews at work in 1948, but only 11 by the middle of 1950. In Europe, work in Germany and Holland was about the same as in 1949, but in Italy an increase was reported to 11 seismic crews, mostly in the Po Valley. In the Persian Gulf area, land work was about the same as in 1949, but marine operations increased, with crews working off the coasts of Saudi Arabia, Qatar, and Bahrein Island.

Geophysical contractors are facing increasing difficulties of operation abroad and at home, due to rising costs of wages, salaries, trucks, machinery, equipment and maintenance. Added to this has come the loss of experienced men to the military services and trouble in securing necessary supplies. Raising contract fees and obtaining deferments will only partially compensate for these difficulties. There is nevertheless reason to hope that the coming year will see a continuation of the present high level of geophysical activity. In fact, increased activity may be expected to measure the success with which new and old problems are solved. There is an increasing awareness, for example, of the problem of multiple reflections, and of the fact that the low relief structures, previously passed up, will require improvements in instrumental accuracy, the application of weathering corrections, and more accurate velocity data. There is evidence that many companies are conducting basic research on seismic wave propagation, demonstrating their realization that progress will depend on acquiring more knowledge of the fundamental processes of the transmission of seismic energy by the earth.

The author expresses deep appreciation to all who unselfishly contributed material for this review.

Sampling the Mining News

- **Sixteen executives, technicians and operative personnel** from the French mining industry, now touring mining operations in the U.S., will wind up their visit to this country at the AIME Annual Meeting. Traveling under ECA auspices, they will be in Denver on Feb. 5, Salt Lake City, Feb. 8 to 13, Bonne Terre on Feb. 16. Four of the group are engaged in bauxite mining, nine in lead and zinc, two in pyrites mining. All are interested in American mining equipment and methods, and hope to contact manufacturers' representatives in the various areas they visit.

- **A $600,000 manganese pilot plant is expected to be** put into operation by Sept. 1, by the Bureau of Mines at Boulder City, Nev. S. R. Zimmerly, chief of the Bureau's metallurgical div. for the region, recently completed the mill design and flow sheet, and the Bureau is awaiting steel priorities before building. Ore from the Artillery Peak area, 60 miles southwest of Kingman, Ariz., will be used in the mill. Construction will be handled by Rex Lloyd of Boulder City.

- **A $325,000 expansion plan for its uranium mills at** Uravan and Rifle, Colo., has been announced by the Electro Metallurgical Div., mining dept., Union Carbide & Carbon Co.—formerly the U.S. Vanadium Co. The Uravan mill will receive the lion's share of the expansion funds—$250,000, and the remaining $75,000 will be spent at Rifle.

- **Our uranium resources are, according to an AEC** representative, proving to be much greater than assumed a few years ago. The Commission is experiencing some success in the Pacific northwest, with most promising showings in the Sunshine mine in the Coeur d'Alene and in the vicinity of Boulder, Mont. Phosphate deposits in Wyoming, Idaho, and Montana constitute, it is said, tremendous low grade uranium reserves which may one day be recoverable as a by-product of phosphate operations. Current developments indicate that silver orebodies may be more closely allied to uranium deposits than any other type, with copper-cobalt ores coming for their share of attention.

- **The National Lead Co. is considering production of** titanium metal at Henderson, Nev., and has leased several buildings at the site of Basic Magnesium, Inc. The company has also contracted with the Colorado River commission of Nevada for power at the site. Expenditure of $15 to $20 million would be required for a plant capable of turning out large quantities of titanium.

- **Colorado Fuel & Iron is opening a new and highly** mechanized coal mine 30 miles west of Trinidad to help meet the need for coking coal at the company's Pueblo steel mills. Access shafts are being built, and a hoist installed. The mine will have two slopes, one with a conveyor belt, and one with the hoist. This development is part of CF&I's $26 million expansion program.

- **Ninety million dollars and two years of work will** go into the Consolidated Mining & Smelting Co.'s new plant at Kimberley, B.C. The company will produce 70,000 tons a year of high analysis aluminum phosphate fertilizer at the plant, using Sullivan concentrator tailing, phosphate rock from Montana, and ammonia from COMINCO's plant in Calgary. Roasters and gas cleaning plant, sulphuric acid plant, phosphoric acid and phosphate fertilizer plant, and shipping buildings will occupy the site just east of the Sullivan concentrator. The new plant represents a 70 pct increase in COMINCO's fertilizer production, and will help fill a big demand from the Canadian prairies for fertilizer.

- **Atlas Powder is cheering its 650 employes for a** record-breaking 5-year span during which 250 million blasting caps were made without a single lost-time injury. The last accident occurred when a worker strained his back in 1945, and since then 6,865,000 man-hr have gone by the board without serious mishap.

- **Certificates of management excellence, awarded by** the American Institute of Management, have been presented to eight metals companies after a continuing study of 2000 leading concerns. Those honored were: Alcoa, Hudson Bay Mining & Smelting Co., Flin Flon, International Nickel, Kennecott Copper, Phelps Dodge, Scovill Mfg., and U.S. Smelting, Refining & Mining. Factors involved in making the awards were—economic function, corporate structure, health of earnings growth, fairness to stockholders, research and development, directorate analysis, fiscal policies, production efficiency, sales vigor, and executive evaluation.

- **Arizona's copper mines are putting a heavy shoulder** to the wheel of world crisis. The Bureau of Mines in Denver reports receipt of over 100 applications for government loans from small Arizona mines which hope to qualify as defense producers. Arizonans are also hopeful of playing a leading role in manganese, tungsten, lead, zinc and asbestos production, with the government ready to step in and make loans to mines promising early production.

- **The Stephens-Adamson Mfg. Co. is marking its** fiftieth anniversary in the bulk materials handling business. Among the company's leading contributions since 1901 are to be found the equipment on the first commercially successful self-unloading bulk freight boat on the Great Lakes, anti-friction, ball-bearing equipped belt conveyor carriers; marketing of the AMSCO manganese steel feeder that has since been installed in 90 pct of all western metal mines, and the centrifugal box car loader.

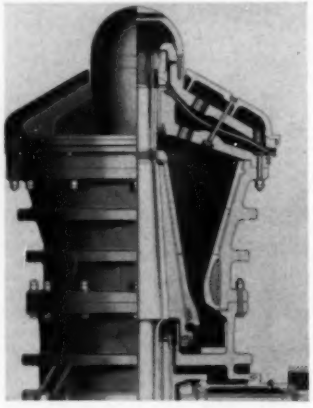
- **The new Phelps Dodge open-pit operation near Bis-** bee, Ariz., will not get under way for several months, although preliminary work has already started. Buildings in the area where the pit will be sunk are being moved, a highway is to be re-routed, and a new Southern Pacific railway station is in the offing. No federal money is to be used in the development.

- **Vacationists will be busy this year—tracking down** radioactive minerals, they say. A New York company has reported an increase in across-the-counter Geiger counter sales; with people from all walks of life admitting to no fear of atomic attack but only a desire to occupy their leisure hours.

- **Commercial synthesis gas may be made directly from** raw coal, Bureau of Mines experiments now indicate. Pilot-plant work at Morgantown, W. Va., has gone "very well" with a high percentage of gasification of the coal. A new and larger gasifier to produce gas from pulverized coal entrained in oxygen and steam is being constructed at the Louisiana, Mo., coal-to-oil demonstration plant.

A-C Offers New Crushers

A new line of gyratory crushers—the "Superior"—for ore and rock products has been announced by Allis-Chalmers. The new machines are made of cast steel, are said to provide increased crushing ability, and greater flexibility of installation and range of adjustment. A cast steel spider hub permits raising of the main shaft as wear progresses on the manganese steel mantle and concaves. Proper use of this feature is said to guarantee that no more than



one resetting of the concaves should be necessary during the life of the alloy crushing surfaces. A weight reduction has been effected by shortening the crusher's vertical discharge bottom shell. Straight down discharge from the bottom shell has made possible the elimination of the diaphragm and its liners. The "Superior" line includes heavy duty and standard primaries, and high capacity secondary crushers in 11 sizes.

G-E High-Speed Generators

An addition to the G-E Tri-Clad Motor and generator line has been announced by General Electric's small and medium motor divisions. Available in four basic designs, the new high-speed synchronous generators have ratings from 1.875 to 50 kva. Designated as Types ATI, ASI, and ATB, the generators have frequency ratings of 60 and 400 cycles. Three standard types of 60-cycle generators are offered, providing a range of characteristics for several different categories of voltage regulation and motor starting requirements. Variations are available with special characteristics.

New Baldwin Strain Gage

A new type of SR-4R bonded resistance wire strain gage, self-compensated for temperature variation, is announced by Baldwin Locomotive Works, Philadelphia. The new strain gages are available for use on Dural and steel in the form of single elements, double elements, and rosettes. Principal advantage of the new self-compensating gage is elimination of a second strain gage to compensate for temperature changes, thus saving application time and wiring. Basically, the new gage is similar to standard bakelite gages with cupronickel wire and its application is by means of the same methods and phenol-resin cement. Gages for two temperature ranges are offered: 50° to 300°F and —50° to +300°F. Single-element gages for Dural or steel are now in stock in four gage lengths: ¼ in., ⅜ in., 13/16 in., and ⅞ in.

Flexible Tubing Expands

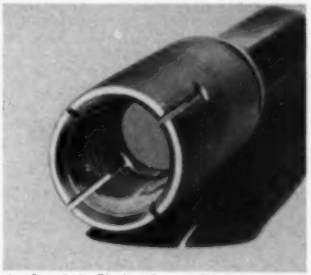
An increased demand for SPIRATUBE Flexible tubing and other flexible duct products has led to expansion of the Flexible Tubing Corp., which recently opened a new and modern plant at Guilford, Conn. F. K. Daggett, company president, explained the expansion as a result of industry's quick recognition of the adaptability of SPIRATUBE as an economical method of transporting air and light solids in all types of industrial activity. In addition to wide use of its lines in mine and tunnel ventilation, materials handling, and dust and fume control the company has also been occupied with orders for the armed forces.

Goodyear Breaks Own Record for Lift Belts

The Goodyear Tire & Rubber Co. recently beat its own record for vertical lift conveyor belts by installing one at the Waltonville, Ill., mine of the Chicago, Wilmington and Franklin Coal Co., with a vertical lift of 868 ft. The belt is 42 in. wide, and is capable of lifting 1200 tons of coal per hr—the equivalent of 24 gondola railroad cars. To produce the belt, the manufacturer used 240 steel cables for a core, with the covers including 75,292 lb of high quality rubber. The entire load, coal and belt, is moved at about 7 mph by a 1500 hp synchronous electric motor. Link-Belt Co. of Chicago built the structure for the belt, installing five impact-cushioning idlers, 38 self-aligning troughing idlers, 681 troughing idlers, 38 self-aligning return rollers and 400 return rollers.

Rock Bit Hole-Saver

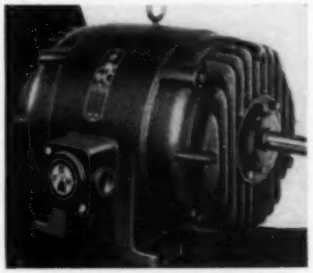
The Rock Bit Hole-Saver is used to reclaim lost bits and drill steel broken off in the hole so as to save redrilling the hole. Attached to a threaded steel in place of a bit, its peculiar left hand, tapered threads cut in the metal of the broken rod and remove it quickly, easily and without jamming. The tool is threaded for Timken H or D; Rock Bit R-1 or R-2 steel to fit the following size



steels: (a) ⅞ in. hex., ⅞ in. Q. O.; 1 in. hex., 1 in. Q. O., 1⅛ in. Rd.; (b) 1¼ in. Rd. and 1⅛ in. Rd. The manufacturer claims that the Hole-Saver has been field proved and rigorously tested.

Extend Fairbanks Morse Line

Fairbanks, Morse & Co., Chicago manufacturers, recently extended their line of type QZE, totally enclosed, non-ventilated, squirrel cage induction motors to include continuous duty ratings built in NEMA standard frame 284. Seven and a half and five hp motors are now in production. These operate at 1800 and 1200 rpm, respectively. These motors conform to NEMA and ASA standards for totally enclosed machines,



and are identical in mounting dimensions with standard totally enclosed fan-cooled motors of the same type. They are said to be well suited for service in locations where dust, dirt, lint, metal turnings and sand are prevalent.

Free Literature

(8) DRILLING EQUIPMENT: Bulletin 33 available from *Acker Drill Co., Inc.* presents in condensed form the complete line of drilling equipment developed during the past 30 years. A complete line of equipment for coal and mineral prospecting, subsurface exploration, diamond and shot core drills, and soil sampling tools are illustrated.

(9) ATMOSPHERE FURNACES: Performance data, engineering construction features and applications of pit-type furnaces for controlled atmosphere heat treatment are described in booklet issued by *Surface Combustion Corp.* The application of the furnaces to heat treatments such as gas case carburizing, homogeneous carburizing, dry cyaniding, clean hardening, and bright annealing are presented. Work handling methods with minimum labor costs and materials handling equipment investment are also given.

(10) PACKAGED GENERATORS: Electrical information, charts, graphs and illustrations to aid in the selection and application of packaged generators are given in bulletin 2100-PRD-202 obtainable from *Electric Machinery Mfg. Co.* Available types of various engine mountings and drives, tables showing types of electrical service provided, and power requirements of motors and voltage dip for a given hp motor are included.

(11) MINING EQUIPMENT: A 62-page pocket-size brochure containing tables on stage of reduction and capacities of crusher, capacities of screens, how to select conveyors and feeders has been issued by *Pioneer Engineering Works.* Facts and figures on equipment for pit, mine, and quarry are included, in addition to information on crushers, screen, feeders, washers, gravel plants, and ore plants.

(12) TRANSMISSION BELTING: To be used as an aid to plant engineers and operating personnel in selecting the right transmission belt to meet individual problems, *Thermoid Co.* has made available bulletin 3678. The bulletin contains complete formulas, charts and tables for proper selection.

(13) EXPLOSIVES: A manual on complete blasting supplies including dynamite, blasting caps, and seismograph electric blasting caps, is available from *Olin Industries, Inc.* Useful information is contained as to standard cartridge count, dynamite per ft of bore hole, resistance of copper wire.

(14) SLIDE-SET VISE: This new vise is built on a new principle and combines advantages of a heavy, conventional type vise with a patented, fast slide action. The jaw slides to any position, open or closed, in one second. No tedious handle spinning is required. Pamphlet may be obtained from *Dodge Mfg. Corp.*

(15) WAGON DRILL: Designed to give the most efficiency in light wagon drill work, Model DR34 is described in booklet available from *Le Roi Co.* It can be used in quarries, open and underground mining, or general road construction work. The patented air feed provides a 7-ft travel or 6-ft steel change. This model will drill flat holes 7½ ft above ground level and toe holes can also be drilled with drill underneath the feed cylinder 4 in. above ground level.

(16) HOISTS: A 16-page booklet released by *Joy Mfg.* describes the complete line of single-drum, multipurpose hoists for mines, construction jobs, oil fields, and industrial plants. Descriptions and specifications for hoists with capacities from 500 to 3500 lb are given. A chart is included to simplify the choice of any hoist to fill a particular need.

(17) pH INSTRUMENTS: This precise measuring of acidity and alkalinity is a vital factor in research, process control, and laboratory analysis. Bulletin 86-G issued by *Beckman Instruments, Inc.* describes the most complete line of pH measuring equipment available.

(18) CONVEYOR BELTS: All belt features as well as significant data on each belt is described in a new 26-page catalog section obtainable from *B. F. Goodrich Co.* Material, oil service, industrial, and special conveyor belts are just a few of the various types illustrated. Cross-sectional diagrams show the various materials that go into the manufacture of these belts.

(19) RESISTANT MATERIALS: A composite catalog available from *National Molded Piping Distributors* describes a free advisory service in connection with the use of corrosion-resistant materials. This company's work is in the more lately accepted plastic and alloyed steel piping used for fluids which attack or are attacked by customary piping materials. Facilities are maintained for the sketching, fabrication or assembly of both plastics and metals.

(20) GRINDING MILL: Bulletin AH-414-31 issued by *Hardinge Co., Inc.* gives full details of this new type of grinding mill, the tricone. Proper ball segregation, less exposed liner surface, lower power requirements, and less floor space are just a few of the advantages of this mill.

(21) DRAINAGE PRODUCTS: A 46-page illustrated manual has been published by *Armco Drainage & Metal Products Inc.*, intended to assist construction engineers, superintendents, and foremen in the proper methods of installing Armco drainage structures, culverts, or conduits. Handling of metal drainage products, location, proper excavation and preparation of base in various types of foundation soils and detailed instructions for assembly of pipe are discussed.

Mining Engineering **February**
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Books for Engineers

Iron Ore Resources of the World (Die Eisenerzvorräte der Welt). By G. Einicke. Verlag Stahleisen, Dusseldorf, 1950. 418 p., with 192 tables and an atlas volume containing 100 p. of maps. 66 German Marks.—A notable work in which the latest available information on iron ore deposits has been compiled by diligent work, continent by continent, country by country. The author reveals the effect of geological formations, iron content of ore, accessability, cost of transportation, political and economic considerations. Ore beds of importance to the German iron and steel industry are given more space than others. The bibliography contains almost 250 references. A tragic comic feature is the author's complaint that as soon as a map of iron ore resources of a country has been completed, the country's boundaries are changed. *Reviewed by W. Trinks, Carnegie Institute of Technology.*

Industrial Research Laboratories of the United States. National Research Council, Washington, D. C. Ninth Edition. 1950. 445 p. $5.—Contains information on the research laboratories of 2845 industrial and commercial organizations, including names of research executives, location of labs, types of activity, whether any consulting services are offered. There are two appendices, one of which lists data on government laboratories which cooperate with industry, and the other naming universities and colleges offering research services to industry.

Bureau of Mines Information Circulars and Reports of Investigations. The following Information Circulars have been released recently by the Bureau of Mines: 7586, Mining and Milling Methods at the Caselton Mine, Combined Metals Reduction Co.; 7587, Evaluation of Converters for Exothermic and Endothermic Catalytic Reactions Occurring Within Narrow Temperature Limits; 7590, Carbon Dioxide Content of Mine-Fire Atmospheres as an Aid When Fighting Metal-Mine Fires. **Reports of Investigations:** 4750, Pilot-Plant Smelting of Ilmenite in the Electric Furnace; 4755, Phenol and Cresols in Coal Tar from Coals Carbonized at 800° and 900°C; 4757, Estimate of Known Recoverable Reserves of Coking Coal in Indiana Co., Pa.

Pre-Historic Mackinac Island. Geology of the Mackinac Straits Region. Occasional Papers on the Geology of Michigan for 1946. State of Michigan. The first-named booklet, consisting of 73 pages, was produced following many queries regarding the origin of the scenic features of Mackinac, and as a result of the public's desire to know more about the geology of the island in Lake Huron. The second publication, 204 pages, represents a study of the surface exposures of the limestones and shales of the Straits area, coupled with a study of the subsurface extension of the rocks under the southern peninsula down to the oil-bearing areas of the south insofar as information was available from boreholes drilled for limestone, oil, gas and water exploration. The third book covers the post-glacial geology of the Grand Marais Embayment in Michigan's Berrien County, as well as the glacial and post-glacial history of the Platte and Central Lake Depression in Benzie County.

Applied Geology. Quarterly of the Colorado School of Mines, Seventy-Fifth Anniversary Volume. Vol. 45 No. 18. 343 p. Maps, illustrations. $3.—Papers delivered at the conferences on applied geology Sept. 30 and Oct. 1, 1949 as part of the school's 75th Anniversary program. Eleven papers are presented here, and three discussions of alteration and its applications to ore research. The papers cover petroleum geology, and various applications of geology to such problems as soil conservation, investigation of water resources, highway engineering, and irrigation engineering.

F.B.I. Register of British Manufacturers. 1950. Third Edition. Iliffe & Sons, Ltd., London. 42 shillings ($5.88). Unique among industrial directories published to promote Britain's export trade, the F.B.I. Register provides a substantial cross-section of the most important producers of British goods in a wide range of industry. It now comprises seven sections: products and services, advertisements, addresses, trade associations, brands and trade names, trade marks, and addenda covering products and addresses of new members of the Federation of British Industries elected after the main sections of the book were printed.

Electric Winders. By H. H. Broughton. Second Edition. E. & F. N. Spon Ltd., London. 451 p. Diagrams, charts and tables, 63s ($8.82).—Intended primarily for the engineering staffs of coal and metalliferous mines, this volume is also of interest to those who design, construct and operate mine hoisting equipment. In this edition, the first since 1927, nearly the whole text is rewritten, and seven new chapters are added. The new material is on Koepe-pulley winders, deep-level winding, intensive hoisting, skip-hoisting of coal, etc. Of special note is the large number of tables and detail diagrams, detailed accounts of failures, and the chapter bibliographies.

Colloidal Dispersions. By Earl K. Fischer. John Wiley & Sons Inc. New York. 1950. 387 p. $7.50.—A study of the dispersion of finely divided solids in liquid media, this book covers the theory and practice of this chemical process, essential in the manufacture of paint, printing ink, pigments, textiles, ceramics, rubber, and many other industrial products. The book provides a detailed account of the practical uses of wetting agents, the operation of mixing equipment and dispersion machinery in mills, and a complete, critical discussion on particle size. The author also discusses several topics previously neglected in colloidal literature, including dispersion by non-aqueous liquids and dispersion by phase transfer, *flushing process.* A leading research worker in the field of surface and colloid chemistry, Dr. Fischer was formerly head of the physical chemistry div. of the Institute of Textile Technology. He is currently chief of the organic coatings section of the National Bureau of Standards.

Geology and Foundation Treatment, Tennessee Valley Authority Projects (Technical Report No. 22). TVA, Knoxville, Tenn., 1949. 548 pp., illus., diagrs., charts, maps, tables. $2. For sale by U. S. Government Printing Office, Washington, D. C.—This book discusses the general geology of the Tennessee Valley area and the integration of the work of engineers and engineering geologists. It presents in detail the choice of the dam site, the geology of the site, and remedial measures in the treatment of foundations for dams and appurtenant structures throughout the Valley. The appendices include a detailed discussion of the leakage problem at Great Falls Dam in the Cumberland River Basin and summary of quarry and river aggregate investigations and use in the TVA construction program. An extensive bibliography is also included.

AIME Salutes

- Officers
  - Directors
    - Division Chairmen
      - Legion of Honor
        - Annual Meeting Chairmen

W. M. PEIRCE
President, AIME, 1951

Willis McGerald Peirce, an AIME member since 1927, will assume the Presidency at the Annual Meeting in St. Louis this month. The new President has been active in Institute affairs for many years, serving as Chairman of the Institute of Metals Div. in 1935, IMD lecturer in 1944, as a Director for seven years, and as Vice-President from 1940 to 1943. Born in Buffalo, N. Y., Mr. Peirce went to Pennsylvania State College, took his B.S. in 1918 from the University of Illinois, and an M.S. from Yale two years later. He had begun his professional career in 1919 and attended Yale on a New Jersey Zinc Co. fellowship. He has been with the company, in Palmerton, Pa., ever since, as a research investigator, as head of the metal research div., and, since 1946, as assistant to the general manager of the technical dept. Noted for his work on zinc and for the research organization he has built up, Mr. Peirce has given freely of his time and knowledge as a contributor to AIME literature. Our new President boasts a son, a daughter, and five grandchildren. Hunting, farming and horseback riding occupy his spare hours.

Joseph Lincoln Gillson became an AIME member in 1923, when he was an instructor in Mineralogy and Petrography at MIT. He had received his B.S. and M.A. degrees from Northwestern and his Ph.D. from MIT, where, by 1928, he was an associate professor. The following year he returned to Northwestern, as associate professor of Economic Geology. In 1930 he joined E. I. du Pont de Nemours & Co., Wilmington. Dr. Gillson was Chairman of the Industrial Minerals Div., AIME, in 1947, and was recently Chairman of the AIME Committee on Democratization.

J. L. GILLSON

M. L. HAIDER

Michael L. Haider was Chairman of the publications committee of the AIME Petroleum Div., for several years, Chairman of the Petroleum Div., in 1945, and active on numerous other committees. He is vice-president and general manager of the production dept. of the Imperial Oil Co. Ltd., Toronto, going there about five years ago from the Standard Oil Co. (N.J.). After graduation from Stanford in 1927, he worked for the Portland Cement Co., the Richfield Oil Co., and the Carter Oil Co.

Leo F. Reinartz, assistant vice-president and manager of the Armco Steel Corp., Middletown, Ohio, has served AIME with great distinction since he joined in 1925. He was Howe Memorial Lecturer in 1943, a Vice-President in 1946 and 1947, and served on the Board of Directors from 1944 to 1948. Perhaps his greatest service has been his 19 successful years of service as Chairman of the National Open Hearth Committee. Born in East Liverpool, Ohio, Mr. Reinartz graduated from Carnegie Institute of Technology in 1909. He went to work for the American Rolling Mill Co. that year, and eight years later became superintendent of open hearth furnaces. By 1938 he was manager of the company.

Thomas Gaunt Moore began his present association with the American Metal Co., New York, in 1935 as field engineer in the mining dept. Following graduation from Harvard in 1931, he became geologist in charge of the Morococha mine of Cerro de Pasco. After three years in Peru, he returned to the Harvard graduate school for his Ph.D., which he was granted in 1936. Dr. Moore has been active in New York Section affairs and was Section Chairman in 1948.

Charles E. Lawall, assistant vice-president of coal properties for the Chesapeake & Ohio Railway, Huntington,

L. F. REINARTZ

C. E. LAWALL

J. F. MYERS

F. W. LIBBEY

A. C. RUBEL

W. Va., was Chairman of the Coal Div., AIME, in 1940, and, with a membership dating back to 1914, has been active in AIME affairs and a frequent contributor to technical literature. Dr. Lawall was made president of West Virginia University in 1939, having been director of its School of Mines. He had been associated with Pittsburgh Testing Laboratories, New Jersey Zinc Co., Bethlehem Steel Co., and Lehigh University.

John F. Myers, superintendent of concentration for the Tennessee Copper Co., Copperhill, Tenn., is one of those who made the organization of the Minerals Beneficiation Div., AIME, a *fait accompli* in 1948, and was its first Chairman. Mr. Myers graduated from Colorado School of Mines in 1913 and went to work for the Butte & Superior Copper Co. He was with American Zinc Co. of Tennessee for a year and New Jersey Zinc Co. for 11 years, joining Tennessee Copper in 1926 as superintendent of milling.

Fay W. Libbey, with the dept. of geology and mineral industries of the State of Oregon in Portland, made his entrance into the mining field in 1906 as night foreman for the Nipissing Mines Co., Cobalt, Ont. Two years later he was superintendent of Vulture Mines Co., Wickenburg, Ariz., going from there to the custom assay office in Phoenix, and then into mine leasing, oil field work, and consulting. He was Chairman of the Oregon Section in 1942.

Albert C. Rubel, vice-president of the Union Oil Co. of California, Los Angeles, got his B.S. from the University of Arizona in time to be assayer for Magma Copper for three months before going into the Army in 1917. After separation from the 304th Engineers, he became geologist for the Commonwealth Petroleum Co. and then the Richmond Levering Co. In 1923 he joined Union Oil Co. as a geologist, becoming a director in 1936.

1951 DIVISION CHAIRMEN NAMED

THESE are the men who have been named to head the various divisions and subdivisions of AIME in 1951. They have all had long and successful careers in industry, and all have made numerous contributions to AIME activities and literature during the years of their membership. They are to be commended for the excellent work they have done thus far, and given the fullest measure of assistance and cooperation in the tasks which lie ahead in 1951.

A. BUTTS

Mineral Industry Education Division

Allison Butts, professor of electrometallurgy, Lehigh University, Bethlehem, Pa. . . . at Lehigh since 1917, as assistant, instructor, assistant professor, and associate professor . . . born in Poughkeepsie . . . A.B. Princeton, B.S. from MIT . . . with U.S. Metals Refining Co. 1913-16 . . . associate editor the *Mineral Industry*, 1920-27 and special editor for Webster's New International Dictionary, 1934 . . . textbook author, plus various other publications . . . member Institute of Metals of Great Britain, Electrochemical Society, ASM, ASEE, Sigma Xi.

T. L. JOSEPH

Iron and Steel Division

T. L. Joseph, assistant dean, Institute of Technology, University of Minnesota, Minneapolis . . . B.A., M.A., University of Utah . . . U.S. Army in World War I . . . Bureau of Mines, 1919-36, as: metallurgical chemist, assistant metallurgist, associate metallurgist, metallurgist and supervising engineer with North Central Experiment Station . . . in 1925 became professor of metallurgy and head of metallurgical dept. at Minnesota . . . J. E. Johnson, Jr., award in 1927 . . . has written numerous articles for Bureau of Mines publications and technical magazines.

R. M. BRICK

Institute of Metals Division

R. M. Brick, director, dept. of metallurgical engineering, University of Pennsylvania . . . at Pennsylvania since 1945 . . . at Yale, 1934-45 as Sterling Research Fellow, instructor in metallurgy, and assistant professor of metallurgy . . . Met. E. from Lehigh, Ph.D. from Yale . . . a variety of papers on physical metallurgy, and textbook, *Structure and Properties of Alloys* . . . Tau Beta Pi, Sigma Xi, Alpha Chi Sigma, AFA, ASM, ASEE, SESA, Institute of Metals (London), Franklin Institute.

R. J. LUND

Mineral Economics Division

Richard J. Lund, supervisor, engineering economics, Battelle Memorial Institute, Columbus, Ohio . . . born

in Racine, Wis., 1905 . . . B.A., M.A. and Ph.D. in geology from University of Wisconsin . . . subsurface correlation work in Oklahoma and Texas oil fields . . . three years as instructor at Wisconsin . . . with the Dept. of Commerce and then the economics branch, Bureau of Mines . . . chapters in the *Minerals Yearbook* on nickel, tungsten, molybdenum, cobalt, vanadium, radium, uranium . . . special studies on scrap metals, and initiated yearly surveys on consumption of scrap iron and steel . . . edited *Mining Congress Journal* 1937-40 . . . during the war headed the miscellaneous minerals branch of WPB in Washington.

C. C. LONG

Metals Branch

Carleton C. Long, since 1937 director, research dept., St. Joseph Lead Co. of Pa., Monaca, Pa. . . . born in Boulder, Colo. . . . B.S. from University of Colorado, M.A. from Stanford, and Ph.D., Colorado . . . in 1930 was control chemist with AS&R at the Durango smelter . . . joined St. Joseph Lead in 1935 as research engineer . . . principally interested in physical and inorganic chemistry . . . publications in the *Journal of Physical Chemistry, Journal of the Optical Society of America,* and the *Photochemical Journal* (England) . . . several articles in American and British mountaineering journals describing high country exploration, first ascents, creation and codification of mountaineering data.

E. D. GARDNER

Mining Subdivision

Eugene D. Gardner, chief mining engineer, Bureau of Mines, Washington, D. C. . . . in mining for 44 years, recently chief, Bureau's oil shale mining division, Denver, Colo. . . . born West Jordan, Utah . . . B.S. and E.M., University of Utah . . . joined the Bureau in 1918 after 5 years with Apex Utah Mining Co. and 7 years geological work . . . in charge of mining division in the western states for 17 years . . . 3 years as regional engineer in Rolla, Mo., and headed oil shale division 1946-49 . . . has authored many Bureau bulletins and magazine articles . . . headed Papers and Program Committee, Mining Subdivision, in 1950.

D. M. DAVIDSON

Geology Subdivision

Donald M. Davidson, vice-president and chief geologist, E. J. Longyear Co., Minneapolis . . . worldwide exploration and development of mineral deposits . . . active in development in Northern Rhodesia copper field . . . B.A. (magna cum laude), University of Minnesota, 1925 . . . M.Sc. (Sigma Xi prize), 1926 . . . Ph.D. 1928 . . . geologist and chief geologist, Rhodesian Selection Trust, Ltd., 1928-33 . . . senior engineer, Selection Trust, Ltd., London, 1933-40 . . . chief geologist, E. J. Longyear, and chief geologist and manager of exploration, 1940-46.

Geophysics Subdivision

Sherwin F. Kelly, director and president, Sherwin F. Kelly Geophysical Services, Inc., Wilmington, Del. . . . born in New Mexico . . . B.Sc. Kansas University . . . attended Université de Paris, Musee d'Histoire Naturelle (Paris), College de France, Ecole des Mines; Toronto University . . . aviator in World War I, and with the American Commission to Negotiate Peace . . . a pioneer in introducing electrical prospecting into the U.S. . . . taught at University of Toronto, 1923-26 . . . manager, Schlumberger Electrical Prospecting Methods, 1927-30 . . . consulting geologist, geophysicist and lecturer on geology and geophysics since 1930 . . . has lectured at Missouri School of Mines, Northwestern, University of Washington, and Lafayette College . . . widely published and belongs to numerous professional groups.

S. F. KELLY

Coal Division

Carroll A. Garner, vice-president, Jeddo-Highland Coal Co. . . . born Ashland, Pa., 1889 . . . B.S. in mining, Pennsylvania State College, 1910 . . . a year with Miami Copper, and one with Inspiration Consolidated Copper . . . instructor in mining at Pennsylvania State 1912-13 . . . 5 years with Lehigh Valley Coal Co. . . . 8 years as assistant general manager at Jeddo-Highland.

C. A. GARNER

Extractive Metallurgy Division

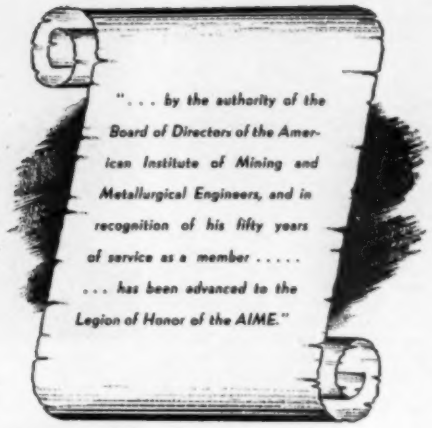
Oliver C. Ralston, chief, metallurgical branch, Bureau of Mines, Washington . . . born Colorado Springs, Colo. . . . B.S., M.E., 1910, Colorado College . . . assayer, surveyor, and instructor in chemistry, Leadville High School . . . Bureau of Mines, Pittsburgh, 1912; Salt Lake City, 1914 . . . assistant chief metallurgist in Seattle, 1920; Berkeley, Calif., 1921 . . . chief, division of nonmetallic minerals, 1935-45; chief, metallurgical branch, since 1946 . . . patents, papers, and books on flotation concentration of ores . . . over 100 contributions to periodicals.

O. C. RALSTON

Industrial Minerals Division

A. B. Cummins, manager of minerals, asphalt and magnesia dept., Johns-Manville Corp., Manville, N. J. . . . born in Los Angeles . . . B.S., University of Chicago, 1920; Ph.D., University of California, 1926 . . . first job "producing blackberries, age 8—profits not bad" . . . research chemist, Celite Corp., 1924-25; then development engineer and research engineer . . . joined Johns-Manville as manager, Celite research, and chemical engineer, 1929 . . . consultant in nonmetallics and industrial minerals since 1932 . . . development of equipment, processes and products in processing of diatomaceous earth . . . also work on air classifications, decolorizing products, heat insulations, magnesia compounds and chemicals . . . patentee and author . . . member ACS, AIChE, ASTM, AAAS, and other groups.

A. B. CUMMINS


". . . by the authority of the
Board of Directors of the Amer-
ican Institute of Mining and
Metallurgical Engineers, and in
recognition of his fifty years
of service as a member . . . . .
. . . has been advanced to the
Legion of Honor of the AIME."

Twenty Five Named to Legion of Honor

THE AIME Legion of Honor rolls will be increased by twenty five at the Annual Meeting in St. Louis, when the following men will be cited for 50 years of membership in the Institute.

H. C. BOYNTON

Henry Cook Boynton . . . born at Willsborough, N. Y. on Apr. 16, 1874 . . . Harvard A.B. 1900 (Magna Cum Laude) . . . Austin teaching fellow in geology 1900-01 at Harvard, in metallurgy, 1902-03 also at Harvard . . . M.S. 1901 . . . Sc.D. 1904 . . . metallurgy and metallography instructor at Harvard . . . did practical economics work in geology and mining . . . member various national and local technical societies . . . John A. Roeblings Sons Co., Trenton, in 1906 until 1940 . . . consulting metallurgist 1947.

A. C. BRINKER

Arthur C. Brinker . . . Colorado State School of Mines, E.M. 1901 . . . Camp Bird, Ltd., Ouray, Colo. until 1910 . . . assisted in examination work of various mines . . . manager of silver-lead and gold-silver mines for London Exploration Co. from 1911 to 1921 . . . approximately eight years devoted to developing and examining properties in North and South America . . . project engineer for Gibbs & Hill, Inc., New York, from 1945 until 1948.

James Francis Brophy . . . born at Pittsburgh in 1872 . . . traveled west working at various mining jobs in 1889 . . . worked in coal and metal mines, railroad shops, and firing locomotives . . . entered Ohio State University in 1893 . . . returned to Butte as mining assistant to engineers . . . graduated from Ohio State in 1899 . . . did engineering work in eastern United States . . . several years later moved to Red Lodge, Mont. and opened coal property . . . also bought group of patented ore claims and staked other groups.

Donald C. Brown . . . graduated Marietta College, Ohio in 1884 . . . several months additional work in mineralogy and assaying . . . following graduation employed by Mexican Ore Co., El Paso, and Catorce, Mexico, 1885-87 . . . Cia Metalurgica Mexicana, San Luis Potosi, 1890; assistant general manager in 1901 . . . in 1915 first vice-president for same concern . . . spent some time in Mexico . . . returned to New York in 1925.

George A. Camphuis . . . born at Newport, Fifeshire, Scotland . . . attended Camborne School of Mines, Cornwall, England, graduated E.M., 1903 . . . employed by English mining companies in Idaho . . . several years with United Mexican Mines Assn. in Mexico . . . manager for Exploration & Mine Development Co., 1913 . . . formed company Camphuis & Rives, El Paso in 1917 doing mine examination and development work . . . several years in mining work throughout southwestern United States . . . worked for Mexican companies, 1923-27 . . . returned to United States, engineering practice in California . . . employed by Cerro Colorado (La Gloria Min.) Chihuahua, Mexico, 1932 . . . manager and consulting engineer Camphuis Engineering Co., Los Angeles, 1936.

George Leonard Collord . . . Princeton graduate 1899 . . . accepted position as chemist for Shenango Furnace Co., Sharpsville, Pa. . . . made assistant superintendent of furnaces . . . joined Clairton Steel Co., now Carnegie Steel Co., as superintendent of blast furnaces . . . general superintendent of blast furnaces, Tennessee Coal, Iron & Railroad Co., Birmingham, 1906 . . . rejoined Shenango Furnace Co. as blast furnace manager . . . made vice-president and general manager.

T. COX

Thomas Cox . . . born at St. Erth, Cornwall, England . . . attended Birbeck Institute, Bedford Park Branch of South Kensington Science and Art Dept., London . . . came to United States in 1883 . . . worked at Gloster mine, Helena, Mont., 1883-88 . . . worked for Woods Larson & Co., railroad construction . . . he remained with this company working on various sites throughout the western part of the country . . . resident managing engineer, Morning mine, Mullan, Idaho . . . he joined the Oregon Waterpower & Railway Co. as assistant engineer in 1902 . . . ensuing years worked on consulting problems, oil and petroleum development work, design and construction of industrial plants . . . during World War I served in Washington, D. C. . . . worked on construction of San Francisco-Oakland Bay Bridge . . . resigned in 1944, since retired.

John Van Nostrand Dorr . . . born in Newark, N. J. . . . worked as laboratory assistant with Thos. A. Edison in Edison's laboratory at Orange, N. J. . . . graduated from Rutgers in 1894 with B.Sc. in chemistry . . . he was engaged for a year in industrial chemical research in New York and then went west . . . for approximately

14 years worked as chemist, assayer, and research worker for various companies in South Dakota, Colorado, and Arizona . . . the Dorr Cyanide Machinery Co. was formed in 1910; in 1916 succeeded by the Dorr Co. . . . his 26 inventions and various modifications have been successfully applied both here and abroad . . . member various technical societies and awarded medals for achievements in both metallurgical and chemical professions.

J. V. N. DORR

L. EATON

Lucien Eaton . . . Harvard University 1900, A.B.; 1901, S.B.; 1902, S.M. . . . engineering dept., Cleveland Cliffs Iron Co., 1902-06 . . . joined Iron Belt & Shores Mines, Iron Belt, Wis. superintendent from 1905 to 1909 . . . worked in various mining companies . . . consultation work in Quebec, 1917 . . . went to Santo Domingo, Peru as resident director, Inca Mining & Development Co. . . . several months were spent in Russia doing consulting work, 1928 . . . connected with the U. S. Bureau of Mines for one year . . . mining engineer for consulting concerns . . . went to Nicaragua in 1937 . . . returned to United States as a consulting engineer in Massachusetts.

J. M. FITZGERALD

John M. Fitzgerald . . . born in Philadelphia, 1877 . . . entered railway service 1893, engineering dept. of the Columbus, Sandusky & Hocking Railroad . . . worked in engineering, construction, maintenance, and operating dept. of the Choctaw, Oklahoma & Guld Railroad . . . joined Virginia & Southwestern Railway as assistant general manager . . . became vice-president of Pittsburgh Terminal Railroad & Coal Co. . . . received Hon. LL.D. from University of Pittsburgh . . . was president, Davis Coal & Coke Co. . . . joined Western Maryland Railway Co. as vice-president; later made president . . . he then became associated with the Eastern Railroad Presidents Conference and is presently vice-chairman.

K. F. GORANSSON

K. F. Goransson . . . studied at the University of Lausanne, 1897-98 . . . practiced at steel work and firms building steam engines for two years in Germany and England . . . one year at Columbia University, New York, received M.A. . . . returned to Sweden in 1901 and joined Sandvik Steel Co. . . . became president in 1920 and chairman in 1929 . . . retired from presidency in 1948 and is now chairman . . . also chairman of Chamber of Commerce of Gavle.

B. Britton Gottsberger . . . born in 1874 . . . graduate of Columbia School of Mines in 1895 . . . employed as assayer for Montsenat Consolidated Mining Co., 1896 . . . joined American Mining Co. of El Oro, Mexico as engineer, 1897-99 . . . engineer with Tennessee Copper Co., 1900 . . . worked for various concerns in mining capacities . . . opened consulting office.

H. R. HANLEY

Herbert R. Hanley . . . born in Paxton, Ill. . . . attended Missouri School of Mines & Metallurgy (University of Missouri), B.S., mining engineering in 1901 . . . met. engr., 1918 . . . joined Bully Hill Copper Mining & Smelting Co. in 1901 . . . assistant superintendent in 1904 . . . made assistant manager in 1908-16 . . . became associated with U. S. Smelting Refining & Mining Co. as superintendent, electro zinc plant, 1916-19 . . . consulting engineer in San Francisco, until 1923 . . . professor of metallurgy, Missouri School of Mines 1923 to date . . . developed various industrial processes . . . authored articles on metallurgy.

Laurier Fox-Strangways Holland . . . born at London, England . . . attended Kings College, London, and School of Mining, Queen's University, Ontario, M.E., 1898 . . . worked in midwest as mining engineer, oil and petroleum geologist, and examining engineer . . . general manager, Guildford Gold Mine, 1934-35 . . . secretary and general manager, Consolidated Leases, Inc. . . . secretary and treasurer, Placerville Gold Mining Co., Placerville, Calif. . . . contributed papers to technical journals.

V. F. S. LOW

V. F. Stanley Low . . . graduated University of Melbourne, bachelor of civil engineering, 1893 . . . joined Mt. Lyell Mining & Railway Co. Ltd., Tasmania, 1894 . . . became assistant engineer in charge of mining dept. . . . one year's experience in mining and concentration work . . . general manager of Hampden Copper Mines, Cloncurry, North Queensland . . . accepted position with Girilainbone Copper Mine, New South Wales . . . worked with several mining companies in Australia . . . went to London and opened office as mining engineer . . . returned to Australia.

William T. MacDonald . . . graduated School of Mines, Columbia University, E.M., 1909 . . . worked in mines and mills in various parts of Colorado and California . . . joined Utah Copper Co. in 1911 as chemist, then metallurgist, and assistant superintendent of Magna mill, Garfield, Utah . . . transferred to Hurley, N. Mex., made assistant superintendent of mills . . . joined Ray Consolidated Copper Co., 1915, assistant superintendent of mills for five years . . . during World War I commissioned in Engineering Corps . . . in 1921 was mill superintendent for Moctezuma Copper Co., Nacozari, Sonora, Mexico . . . joined International Nickel Co., Ontario in 1929 . . . moved to La Jolla, Calif. in 1936, presently located there.

Ernest A. Manners . . . born in Posen, Germany . . . Technical School, Breslau, Germany, 1884 . . . worked in gold fields and silver mines in Australia . . . returned to Germany in 1888 . . . engaged in mining work in South Africa . . . in 1890 did exploring work in Australia . . . consulting engineer for New Zealand Mines Trust in 1898 . . . made general manager and consulting engineer for Howell Exploration Co., Ltd., 1900 . . . remained there and later went to England.

Herbert A. Megraw . . . Cornell University graduate B.S., 1898 . . . years following were spent working in mines in Mexico . . . worked on editorial staff of *Engineering & Mining Journal* for approximately five years . . . Bureau of Aircraft Production, Washington, D. C., 1918 . . . joined engineering concern in New York . . . vice-president, Crown Oil & Wax Co., Baltimore, 1922 . . . went to Seville, Spain in 1927 for several years . . . returned to Baltimore in 1936.

F. L. MORRIS

Fred L. Morris . . . born at Paris, Ill., graduated College of Mines, University of California, B.S., 1900 . . . employed in drift mines of Placer County, Calif. . . . reported on properties in Mexico . . . also employed in dredging work for Oroville Gold Dredging & Exploration Co. . . . opened consulting office in San Francisco in 1906.

Horace Moses . . . attended New Mexico Western College . . . employed 1900-09 various capacities from miner to mine foreman . . . became superintendent of mines for Chino Copper Co., Santa Rita, N. Mex., 1909-17 . . . general superintendent and general manager, Gallup American Coal Co., Gallup, N. Mex. for 20 years . . . joined Kennecott Copper Corp., Chino mines div., Santa Rita, general manager for 10 years . . . retired from active business in 1947.

H. MOSES

Arthur C. Spencer . . . studied at Case School Applied Science, Cleveland, 1889-92 . . . graduated 1902 as bachelor of science . . . student at Johns Hopkins University for one year . . . investigated coal deposits connected with Iowa Geological Survey . . . received Ph.D. in geology 1896 from Johns Hopkins University . . . appointed assistant geologist, U. S. Geological Survey, 1896 . . . geologist in 1901 with Bureau, remained until retirement.

A. C. SPENCER

Alexander N. Winchell . . . University of Minnesota, B.A., 1896; M.S., 1897; University of Paris, D.Sc., 1900 . . . professor of geology and mineralogy, Montana School of Mines, seven years . . . 1908-44 professor mineralogy and petrology, University of Wisconsin . . . resident consultant, American Cyanamid Co., 1945.

A. N. WINCHELL

Lewis E. Young . . . born in Topeka . . . graduated Pennsylvania State College, B.S., mining engineering, 1900 . . . Iowa State College, E.M., 1904 . . . University of Illinois, Ph.D., 1945 . . . University of Missouri, D.Eng., 1947 . . . instructor at Iowa State College, 1900-03 . . . four years professor of mining, Colorado School of Mines . . . consulting engineer for four years . . . 1907-13, director, Missouri School of Mines . . . special field work, Illinois Geological Survey . . . one year as professor of business administration . . . joined Union Colliery Co., St. Louis as mining engineer . . . general manager, 1922-26 . . . production vice-president, Pittsburgh Coal Co., Pittsburgh, 1927-39 . . . consulting mining engineer, Pittsburgh 1939 to date . . . author technical papers on mine mechanization and practice . . . spent a busy year in 1949 as AIME President, visiting a very large number of Local Sections . . . he was a Director in 1937, served three terms on the board, and was Vice-President from 1942 to 1945.

L. E. YOUNG

H. P. Townsend . . . born King Williams Town, Cape Colony . . . three years at Royal School of Mines, South Kensington . . . obtained associateship in 1893 . . . several years surveyor and assayer . . . general manager mining company in Rhodesia . . . employed in South Africa, 1923 . . . New Modderfontein Gold Mining Corp., Ltd., Van Ryne, Transvaal, 1940.

Charles Henry White . . . University of North Carolina, S.B., 1894 . . . Harvard University, S.B. (Magna Cum Laude), 1897; A.M., 1902 . . . instructor, assistant professor, professor of mining and metallurgy, Harvard University for 17 years . . . Captain in Ord. Dept., 1918-19 . . . consulting geologist in San Francisco for several mining companies, 1919-27 . . . several years spent abroad as consulting geologist for various concerns . . . private practice since 1938.

Dr. Compton to Address Annual Meeting Welcoming Luncheon

A. H. COMPTON

Arthur Holly Compton, Nobel-prize winning physicist who is famed for his work on the development of the atomic bomb, will be the principal speaker at the Welcoming Luncheon on Feb. 19. Dr. Compton of Washington University in St. Louis took the Nobel prize in 1927 for his discoveries concerning X-rays, and again came into prominence between 1931 and 1934 when he directed a worldwide study of cosmic rays. Later, he was assigned to the Manhattan Project, working on design of the atom bomb and the use of plutonium as an explosive agent. He started and directed development of the first atomic chain reaction, and served as chairman of the National Academy of Science Committee to evaluate the use of atomic energy. Dr. Compton is vice chairman of the U. S. National Commission for UNESCO, and was U. S. delegate to gatherings of this group in Washington and Mexico. He is now a trustee of the Institute of International Education, Inc. These facts represent only the highlights of a long and noteworthy career, and there is, unfortunately, a lack of space in which to list the numerous honors bestowed upon Dr. Compton by educational, scientific and government groups all over the world.

Student Forum at Washington University

The Careers Forum for students to be held on Thursday, Feb. 22, will meet at Washington University, and not at the University of Missouri as was claimed on P. 65 of the January issue.

Annual Meeting Committee Chairmen

H. I. YOUNG
Chmn., Gen'l Comm.

F. J. MEEK
Secy., Gen'l Comm.

N. L. SHEPARD
Chmn., St. Louis Sect.

Behind the scenes at every meeting and convention are those who have laid the groundwork for the activities. They appear calm and unruffled as the meeting opens, but behind them are months of planning, red tape cutting, and several hundred letters, telegrams and memoranda.

Pictured here are some of those men to whom is owed a vote of thanks for the top-notch planning that has gone into the AIME Annual Meeting, to be held in St. Louis, Feb. 19 to 22, 1951.

Space limitations preclude introducing each and every committee member and chairman individually—but they'll all be there in St. Louis, where you can have the pleasure of meeting them in person.

Committee chairmen whose pictures were not available include: J. D. Kerr, Banquet; L. P. Davidson, Welcoming Luncheon; E. L. Clark, Field Trips; Mrs. H. I. Young, Women's Auxiliary; C. G. Stifel, Finance.

Made your meeting reservations yet?

K. A. PHILLIPS
Chmn., Informal Dance

H. A. FRANKE
Chmn., Dinner-Smoker

C. TOLMAN
Chmn., Reception

A. B. CLEAVES
Chmn., Publicity

C. L. WILSON
Student Activities

AIME Annual Meeting Program, February 19-22, 1951

Jefferson and Statler Hotels, St. Louis

To conserve space especially because of the numerous joint sessions of two or three groups, the names of Divisions and Subdivisions are coded, as follows: MIED—Mineral Industry Education Division. MED—Mineral Economics Division. M—Mining Subdivision. G—Geology Subdivision. Geophys—Geophysics Subdivision. NM—(Nonmetallics) Industrial Minerals Division. Coal—Coal Division. MBD—Minerals Beneficiation Division. IMD—Institute of Metals Division. ISD—Iron and Steel Division. Petroleum Branch—named as such. SEG—Society of Economic Geologists.

Saturday, February 17

10 am to 5 pm—Council of Section Delegates.

Sunday, February 18

2 pm—Board of Directors.
2:30 pm—MIED.

7:00 pm—MIED.

Monday, February 19

8:30 to 8:45 am—Meeting of presiding officers and authors.

9:45 am to 12 m

Petroleum Branch—*Executive Committee.* 9:00 am to 11:45 am.
EMD—*Lead; Miscellaneous.*
IMD—*Martensite.*
ISD—*Sulphur.*
NM, G, SEG—*Clay.*
MBD—*Business Meeting.*
Coal—*Depreciation Problem.*
NM—*Canadian Industrial Minerals.*
MIED.
10 am—Metals Branch Council.

12:15 pm—Welcoming Luncheon. Speaker, Arthur Holly Compton.

2:30 pm

MED—*Foreign Minerals.*
M, G—*Geology and Mining Methods.*
Coal—*Depreciation Problem.*
NM—*Canadian Industrial Minerals.*
NM, G, SEG—*Clay.*
G, SEG—*Symposium on Ground Water.*
Petroleum Branch—*Executive Committee.*
MBD—*Materials Handling; Solid-fluid Separation.*
EMD—*Zinc; Miscellaneous.*
EMD—*Aluminum; Magnesium.*
IMD—*Martensitic Transformation.*
ISD—*Sulphur.*

Evening—Dinner-Smoker.

Tuesday, February 20

8:30 to 8:45 am—Meeting of presiding officers and authors.

9:00 am to 12 m

MED, M, G, Geophys—*Exploration Costs.*
M—*General Session.*
G, SEG—*Orebody Manifestations.*
MBD—*New Milling Equipment.*
Coal—*General Session.*
NM—*Dimension Stone.*
NM—*Clay.*
Petroleum Branch—*Production Review.* (8:30-11:00 am)
EMD—*Zinc and Lead from Slag.*
EMD—*Titanium.*
IMD—*Recrystallization.*
ISD—*Sulphur.*
10 am—Mining Branch Council Women's Auxiliary *Annual Meeting.*
10 am—Mining Branch Council. Business Meeting.

11 am—Howe Lecture by J. R. Vilella. Statler Ballroom.

12:15 — Luncheons

Mineral Economics Division.
Mineral Industry Education Division.
Mining, Geology, Geophysics Division.
IMD—*Executive Committee.*

2 pm

NM—*Lightweight Aggregates.*
NM, M—*Mining Methods.*
MBD—*Concentration.*
G, SEG—*Orebody Manifestations.*
Coal—*General Session.*
EMD—*Zinc and Lead from Slag.*
EMD—*Titanium.*
ISD—*Sulphur.*

2:30 pm

Petroleum Branch—*Waterflooding in the Illinois Basin.*
MED—*Taxation, Tariffs, Subsidies.*
IMD—*Diffusion and Precipitation.*

4 pm—Annual Business Meeting.
4 pm—Executive Committee, Coal Division.
5 pm—Directors' Meeting *Executive.*

Evening

Metals Branch Dinner (IMD, ISD and EMD), Statler Hotel.
Petroleum Branch Dinner. Statler Hotel.
Informal Dance. Jefferson Hotel.
SEG Banquet. Jefferson Hotel.

Wednesday, February 21

8 am to 9:15 am—"Scotch Breakfast," MBD.
8:30 to 8:45 am—Meeting of presiding officers and authors.

9 am to 12 m

M—*Mining Methods.*
MBD (9:30 am)—*Crushing and Grinding; Operating Controls.*
Coal *Preparation.*
Coal, SEG—*Geology.*
NM, G, SEG—*Clay.*
NM—*General Session.*
Geophys—*General Session.*
Petroleum Branch (9:15 to 11:30) —*Drilling, Logging, Acidizing.*
ISD (9 to 10:45 am)
EMD—*Electrolytic Zinc.*
EMD—*Copper; Cobalt; Refractories.*
IMD (9 to 10:45 am)—*Phase Transformation.*
IMD (9 to 10:45 am)—*Plasticity and Mechanical Properties.*

10 am—Women's Auxiliary *Round Table.*

10:45 am—IMD *Annual Business Meeting.*

11 am—IMD *Annual Lecture by G. Borelius. Statler Ballroom.*

12:15 — Luncheons

Coal Division.
Industrial Minerals Division.
EMD Executive Committee.
Physical Chemistry of Steelmaking.
Mining and Metallurgical Society of America.

2 pm

NM, G, SEG—*Clay.*
M—*Mining Methods.*
MED, NM—*Cost Accounting in Mining.*
Coal, SEG—*Geology.*
G, SEG—*Geology General Session.*
Geophys—*General Session.*
Petroleum Branch (2:15 pm)—*Reservoir and Production Engineering.*
EMD—*Physical Chemistry.*
EMD—*Electrolytic Zinc.*
IMD—*Alloy Systems.*
IMD (2:30 pm)—*Grain Boundaries and Annealing Twins.*
ISD (2:30 pm)—*Joint Session with Southwestern OH Section.*

4:45 pm—EMD *Annual Business Meeting.*

5 pm—Executive Committee, Industrial Minerals Division.

Annual Banquet and President's Reception.

Thursday, February 22

8:30 to 8:45 am—Meeting of presiding officers and authors.

MED, NM—*Economics of Industrial Minerals.*
NM—*General Session.*
EMD—*Physical Chemistry.*
EMD, MBD—*Joint Technical Session.*
IMD—*Powder Metallurgy.*
IMD—*General Session.*
ISD—*General Session.*

12:15 — Luncheons

Minerals Beneficiation Division.
Powder Metallurgy Committee.
ISD Executive Committee.

2 pm

MBD (2:30 pm)—*Clean-up Session.*
EMD—*Physical Chemistry.*
IMD—*Powder Metallurgy.*
Careers Forum for Students.

Friday, February 23

Field Trips.

High-Speed Classification and Desliming With the Liquid-Solid Cyclone

By D. A. Dahlstrom

Application of the cyclone to separation of undesirable —200-mesh clay, silt, and high-ash fractions from coal slurries was found to possess many economic and process advantages. Up to 93.3 pct removal was attained at rates of 113 to 155 gpm per sq ft of cross-sectional area.

WITHIN the past decade, certain economic, legal, and technological changes have intensified the necessity for an efficient classifier or deslimer of particles at and below the 200-mesh point. First, mechanization of mining has increased the percentage of clays, silts, refuse, and high-ash material in the run-of-mine coal. Second, many washing plants must rely on smaller percentages of fresh make-up water because of shortages, economic factors, or legal restrictions on waste water disposal. Finally, the crushing of middlings and coarse refuse plus the trends toward the finer sizes in sales has further increased the amount of fines produced per ton of mine-run coal.

A joint consequence of these circumstances has been the augmented percentage and build-up of —200-mesh material in the finer coal fractions and tipple circulating water. This results in the following disadvantages to the operator: (1) Higher ash percentages in the fine coal caused in large measure by the greater ash content of the —200-mesh material, (2) more difficult or expensive recovery of the fine coal from plant slurries, (3) lower filtration, drainage, and drying rates caused chiefly by lower permeability and the greater surface exposed per unit mass of the finer particles, (4) greater difficulty of beneficiating the fine coal because of lowered equipment efficiency and the partial "coating-out" of the —200-mesh fraction on the coarser coal particles. Obviously some cheap but effective fine-size classifier must be developed to aid in solving the above problems.

To eliminate the generally unwanted —200-mesh fraction from coal slurries, several methods are in use. Probably the most popular with coal operators is the settling cone wherein the larger particles settle downward to the apex of an inverted cone while the slimes and fines are carried upward by vertical fluid currents caused by the overflow of the bulk of the water at the outer rim. The main advantage of the unit is the low initial and operating cost since no moving parts are involved. Disadvantages are primarily low capacity per square foot or floor space and the loss of good coal in the overflow above the 100-mesh size due to localized, high-velocity gradients and nonuniform, fluid-flow patterns, especially at high loadings. Also, when high slime concentrations are present, desliming efficiency is severely injured.[1, 2]

Other methods employed are the drag and spiral classifiers and the hydroseparator.[1] These involve mechanical separations achieved by moving parts and naturally result in higher initial costs. As they are all based on the settling velocity of the particles at the mesh of separation under operating conditions, area requirements are again large per gallon of throughput if they are to classify at the 200-mesh point. Usually the selection is made to operate at a higher throughput and thus sacrifice some coarser coal in the slime overflow.

Cyclone Possibilities in Desliming

To overcome the disadvantages of present desliming methods, it is necessary to use a device that exhibits a very stable and uniform flow pattern while greatly increasing the settling velocity of

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This page of Transactions is a continuation from p. 84. The missing pages appeared in Mining Engineering.

Fig. 1—Experimental desliming equipment.

the 200-mesh particle. Fortunately, the inexpensive cyclone containing no moving parts possesses both of these qualities. Basic operation and design principles have been well formulated by several authors.[3-9]

The desired symmetry and uniformity of velocity gradients within the cyclone have already been established by Criner.[5] For one specific gravity material each diameter particle will have a definite radius within the cyclone where concentration occurs. At this point the centrifugal force acting on the particle caused by the tangential velocity, radius of curvature, and particle mass is exactly balanced by the opposite frictional resistance forces due to the radial flow of the fluid past the particles toward the cyclone core. Both forces increase with a decrease in radius of curvature, but the former at a higher rate. Thus, particles coarser than the mesh of separation for the classification will tend to congregate at radii equal to, or less than, the cyclone radius, while finer particles are concentrated primarily at radii approximating the magnitude of the cyclone overflow. The result is a relatively sharp separation for particles coarser than mesh of separation when the cyclone operates at a low, underflow, volume split. Under this condition only the larger concentrating radii particles report 100 pct to the cyclone underflow while, simultaneously, the smaller radii particles are more completely carried into the cyclone overflow. Criner[5] has given a detailed discussion of the phenomenon.

The high centrifugal force (up to 2000 times that of gravity) that occurs within the cyclone has been pointed out by several writers.[4, 5, 7-9] This results in greatly increased settling velocities for all particles and accounts for the extremely high capacities of 200-400 gpm per sq ft of area obtainable with the cyclone. In fact, acceleration of terminal velocities is so great, the critical separation size for a cyclone operating with normal efficiencies will vary from approximately 10 to 30 microns for solids found in industrial slurries. Thus, the problem is actually to make the cyclone operate with less efficiency in order that the separation point can be raised to the 50 to 75 micron size and thereby perform a suitable desliming operation.

It has been demonstrated[4] that larger inlet and overflow nozzles, greater cyclone included angles, and smaller inlet rates all contribute toward a less efficient cyclone. Furthermore, particles, which are so fine that they experience no concentrating action, theoretically will act as a dissolved solid and thus report to underflow and overflow in the same weight ratio as the slurry water. This will be true to a lesser degree for particles slightly below the separation point. Consequently, water percent to the underflow must be held to a minimum consistent with the maintenance of the necessary vortex discharge for maximum rejection of slimes to the overflow. For coal slurries, underflow, solid content of 50 to 55 pct is probably optimum for this specification.

Some method must be found to estimate cyclone design, nozzle dimensions, and feed rates for a desliming operation. An equation for the prediction of the 50 pct point (the particle size that reports in equal weights to underflow and overflow streams), which is another name for the critical separation size or mesh of separation used in classifier terminology, had been previously obtained[4] as

$$\mu = \frac{81\,(be)^{0.60}}{(G)^{0.50}} \left[\frac{1.73}{\rho_s - \rho}\right]^{0.5} \qquad [1]$$

for a 20° cyclone with a vortex discharge. The expression is applicable to cyclone design but is so far only valid for high efficiency cyclones with 50 pct points from 8 to 30 microns. These particles appear to act according to Stokes' law under the conditions of operation, while those near the 200-mesh size will definitely deviate from this law under the increased gravitational force. Until experimental work now in progress is completed, which should develop an equation which will predict separation values accurately for desliming purposes, eq 1 must serve as a good first approximation in estimating cyclone dimensions and rates for desliming design.

The 50 pct size of eq 1 is based on an equivalent diameter particle (diameter of a sphere of same settling velocity and specific gravity as the particle in question). As coal and mineral material will be nonspherical, causing such particles to fall at a lesser rate than the same screen-size spheres, settling velocity tests should be performed if great accuracy is desired. An equivalent diameter of 75 pct to 85 pct of the actual screen diameter is a good general average. The equation was also indicated as predicting critical size values 20 pct below those determined

Nomenclature

- b = cyclone inlet diameter, in.
- D = particle diameter, microns
- e = cyclone overflow diameter, in.
- F = cyclone energy loss, ft of fluid
- G = slurry feed rate, gpm
- Gpm = slurry feed rate minus underflow solids in a 50 pct slurry, gpm
- K = Capacity equation proportionality constant = $[\text{gpm}/\sqrt{F}] + (\text{eb})^{0.6}$
- ρ = fluid specific gravity, g per cc
- ρ_s = solid specific gravity, g per cc
- μ = 50 pct particle size, microns

by subsieve size distribution tests on underflow and overflow streams of industrial cyclone installations. This is due to the wide range of specific gravity solids found in such slurries, making it extremely difficult to determine size analysis accurately below the 200-mesh size. It should be emphasized that the multiplying factors do not detract from the validity of the equation. Actually, equivalent diameter is a more useful measurement than screen dimension since it accurately and simply portrays how the particle will move in a fluid slurry. The safety factor used for industrial slurries is an expediency which eliminates the necessity of breaking the —200-mesh fraction into several smaller specific gravity ranges in order to determine the 50 pct point for *each* specific gravity involved. This would be time-consuming and expensive.

Test Procedure and Equipment

To test desliming possibilities, a 9-in. cyclone was selected which had been utilized in a previous study.[4] The unit possessed interchangeable inlet, underflow, and overflow nozzles, and included angle, permitting investigation of all previously mentioned variables. It was decided to use the largest overflow and inlet nozzles (2.5 and 2.067 in., respectively) for the base comparison tests since this would give maximum aid in raising the 50 pct point predicted by eq 1. Furthermore, a better idea of capacity per unit area would be available. Also in eq 1, from experience, specific gravities of the —200-mesh fraction containing slimes and high-ash coals will run 1.7 to 2.0, so that an average value of 1.85 was selected. A fluid density of 1.0 was assumed, although this would have to be altered if high-solid-concentration feeds were used. Finally, it was decided to designate the entire —200-mesh fraction as slimes for these tests, since generally it will be desirable to eliminate totally this material. Furthermore, if the coarser particles of this fraction are desired, a higher efficiency cyclone, which is already in industrial operation, will serve this purpose. Thus, the critical size of separation will be a screen diameter of 75 microns, which must be multiplied by two safety factors of 0.8, as previously indicated. By eq 1, the flow rate necessary for the proposed cyclone can be approximated.

$$\mu = 75 \times 0.8 \times 0.8 = 48 \text{ microns}$$

$$b = 2.067 \text{ in.} \qquad \rho_s = 1.85$$

$$e = 2.5 \text{ in.} \qquad \rho = 1.0$$

$$\text{and } (G)^{0.5} = \frac{81}{48}\,(2.067 \times 2.5)^{0.5}\left[\frac{1.73}{1.85\text{-}1.0}\right]^{0.5}$$

from which $G = 42$ gpm.

Probably slightly higher feed rates can be used as any deviation from Stokes' law would tend to increase the 0.5 exponent of eq 1. Accordingly, most test work for maximum elimination of —200-mesh material was conducted at input volumes of 45 to 60 gpm.

The 9-in. cyclone was installed, as shown in Fig. 1, above a 200-gal supply tank. The cyclone was fed by a slurry pump connected to the tank through a gate valve used to throttle the flow to the desired rate. Both underflow and overflow streams returned to the tank, which was kept thoroughly mixed by a highspeed agitator. Equilibrium was easily established in less than 1 min for all runs. Test material was furnished by the Truax-Traer Coal Co. from two sources. The first was taken from the overflow of the drag tank going to the desliming tank at their Burning Star mine in Illinois, while the second originated from the slurry pond at the Fiatt, Ill., tipple at a considerable distance from the discharge pipe in order to obtain a preponderance of slimes.

Judging Desliming Efficiency

Some basis or standard must be designated in order to judge efficiencies properly. When no fresh or hydraulic water is introduced to any deslimer,

Table I. Representative Desliming Results 9 in., 20° Cyclone without Hydraulic Water

	Run 1, Burning Star Solids			Run 2, Mixed Solids		
	Feed	Overflow	Underflow	Feed	Overflow	Underflow
Nozzle diam, in.	2.067	2.5	0.75	2.067	2.5	0.75
Line pressure, lb. per in.^{2}	not taken			1.56		
Volume rate, gpm	39.4	24.7	4.7	48.72	41.3	7.42
Water rate, gpm	26.85	24.2	2.65	43.75	39.6	4.15
Solid rate, tons per hr	0.97	0.23	0.74	1.83	0.68	1.15
Solid concentrate, wt pct	12.55	3.67	52.6	14.3	6.40	32.5
Ash, wt pct of solids	18.21	39.51	11.61	31.50	61.97	13.53
Solid distribution, wt pct	100.0	23.9	76.1	100.0	37.1	62.9
Ash distribution, wt pct	100.0	52.0	48.0	100.0	73.1	26.9
Water distribution, wt pct	100.0	90.1	9.9	100.0	90.5	9.5
Desliming coefficient	1.41			1.27		
Capacity ratio, K[a]				5.15		
Screen analysis, U.S. standard, wt pct						
+40-mesh	29.7	trace	52.1	34.8	trace	55.3
40x60	20.9	0.1	27.5	13.8	0.2	21.9
60x100	9.0	1.1	11.5	6.9	0.9	10.5
100x140	2.8	3.9	2.4	2.6	2.2	2.8
140x200	3.0	6.2	2.0	2.3	2.9	1.9
—200 (slimes)	24.6	88.7	4.5	39.6	93.8	7.6
Size distribution, wt pct						
+40-mesh	100.0	0.0	100.0	100.0	0.0	100.0
40x60	100.0	0.1	99.9	100.0	0.5	99.5
60x100	100.0	2.9	97.1	100.0	4.7	95.3
100x140	100.0	33.6	66.2	100.0	31.7	68.3
140x200	100.0	49.3	50.7	100.0	47.4	52.6
—200 (slimes)	100.0	86.1	13.9	100.0	87.9	12.1
Ash content, wt pct						
+40-mesh	6.29		6.29	5.78		5.78
40x60	9.40	3.71	9.42	8.70	2.67	8.71
60x100	15.28	4.54	15.53	14.66	3.78	15.31
100x140	17.00	4.84	23.61	18.02	4.39	20.49
140x200	24.92	7.29	42.10	25.93	6.24	44.24
—200	45.40	43.84	54.12	66.22	65.92	69.43

[a] K = capacity equation proportionality constant = gpm / $\sqrt{p}$ ÷ $(ab)^{0.5}$, where F = cyclone energy loss, feet of fluid.

maximum elimination of a particle size to the overflow will occur when no concentration of that size takes place within the unit. The particle size then will report to the overflow and underflow stream in the same weight ratio as the water split. In this study, it is desirable to reject all the —200-mesh fraction possible, as it has been designated a slime. Thus, the first basis of desliming efficiency will be the comparison of water and —200-mesh split between overflow and underflow. Therefore, a term entitled "desliming coefficient" was used, which is merely the quotient of the percent of feed —200-mesh solids found in the underflow divided by the percent of total water reporting to the underflow. It would be desirable to make the coefficient approach zero for perfect desliming, but with no addition of hydraulic water, 1.0 will be the minimum value. While this coefficient accurately illustrates the efficiency of slime elimination under the condition of operation, it is by no means the only element to consider. Other factors, such as loss of desirable +200-mesh material to the overflow, moisture content of underflow solids, water split to underflow, feed solid concentration, cyclone capacity, and any other important operating conditions, must be given conjunctive treatment.

Test Results

Tests were performed first at normal solid loadings to the cyclone (between 12 and 15 pct solids) under the previously calculated conditions. Results are given in Table I. Run 1 was performed on the Burning Star solids, while Run 2 contained an equal amount of Fiatt material. This latter mixture was deemed more advantageous for these tests since it yielded a —200-mesh content of 40 pct by weight of total solids and thus indicates results under severe size distribution operation.

Relatively little concentration of the —200-mesh fraction in the underflow occurred as shown in Table I. Desliming coefficients of Runs 1 and 2 were 1.41 and 1.27 with the elimination of 86.1 and 87.9 pct of the slimes, respectively. Water splits were less than 10 pct to the underflow with moisture contents of both underflow solids at about the probable maximum. The higher desliming coefficient (thus the poorer desliming efficiency under operating conditions) of Run 1 was believed primarily due to the larger content of heavy quartz, calcite, and pyrite grains present near the 200-mesh size in the Burning Star solids. It would not be economically advantageous to reject such material by classification as considerably coarser coal particles would then escape to refuse. For example, let us assume a 75-micron particle of quartz (2.65 sp gr) is to be eliminated in the overflow of the classifier operated under "free settling" conditions with fluid specific gravity of 1.0. As a rough estimate of the top size of 1.4 gravity coal that would be simultaneously lost in the classifier overflow, the common classification ratio may be used.[1] Thus,

$$\frac{D_1}{D_2} = \frac{(\rho_{s2} - 1)}{(\rho_{s1} - 1)}$$

where D_1 = diameter of coal particle, microns
$\rho_{s2} = 2.65$ (quartz sp gr)

D_2 = diameter of quartz particle = 75 microns
$\rho_{s1} = 1.4$ (coal sp gr)

and $$D = 75 \frac{(2.65 - 1)}{(1.4 - 1)} = 310 \text{ microns}$$

310 microns is approximately a 45-mesh particle. Loss of substantial quantities of this coal certainly could not be tolerated. Therefore sand particles near the 200-mesh point cannot be eliminated in the overflow by any classifier without loss of some desirable coarse coal. At the same time, efficient elimination of true clays and silts possessing approximately the same specific gravity as quartz can be achieved since this material generally lies below 40 microns in size. Coarser high-ash coal in the —200-mesh fraction will be rejected to the overflow since it possesses a lower specific gravity.

Appreciable amounts of 100 x 200-mesh low-ash coal are lost to the overflow as indicated by size dis-

Table II. Representative Desliming Results 9 in., 20° Cyclone with Hydraulic Water

	Run 3, Burning Star Solids			Run 4, Burning Star Solids			Run 5, Mixed Solids			Run 6, Mixed Solids		
	Feed	Overflow	Underflow	Feed	Overflow	Underflow	Feed	Overflow	Underflow	Feed	Overflow	Underflow
Nozzle diam, in.	2.067	2.5	0.75	2.067	2.5	0.75	2.067	2.5	0.75	2.067	2.5	0.75
Line pressure, lb per in.²	2.0			2.0			1.88			2.0		
Volume rate, gpm	50.7	43.1	7.04	49.8	46.9	7.57	48.5	46.5	6.70	48.6	47.3	6.0
Water rate of slurry, gpm	46.8	47.5	3.97	45.6	46.0	4.3	44.2	45.1	3.8	44.8	46.1	3.44
Hydraulic water rate, gpm	4.7	(one inlet port)		4.7	(one inlet port)		4.7	(one inlet port)		4.7	(two inlet ports)	
Solid rate, tons per hr	1.37	0.29	1.08	1.42	0.29	1.13	1.67	0.69	0.98	1.58	0.68	0.90
Solid concentrate, wt pct	10.48	2.41	82.0	11.10	2.46	51.4	13.06	5.76	50.5	12.32	5.55	51.1
Ash, wt pct of solids							31.31	59.54	11.54			
Solid distribution, wt pct	100.0	21.4	78.6	100.0	20.4	79.6	100.0	41.3	58.7	100.0	43.0	57.0
Ash distribution, wt pct							100.0	78.6	21.4			
Water distribution, wt pct	100.0	92.3	7.7	100.0	91.5	8.5	100.0	92.2	7.8	100.0	93.0	7.0
Hydraulic water, pct of total water	9.1			9.4			9.6			9.5		
Desliming coefficient	1.39			1.32			0.87			0.96		
Capacity ratio, K	5.25			5.15			5.28			5.18		
Screen analysis, U.S. standard, wt pct												
+40-mesh	48.1	0.0	62.5	48.0	trace	61.5	34.4	trace	38.6	30.8	trace	54.0
40x60	17.4	trace	22.1	18.1	0.2	22.7	13.6	0.2	23.0	14.9	0.2	26.0
60x100	7.3	3.4	8.4	8.3	4.0	9.4	6.5	2.2	9.5	6.9	1.8	10.7
100x140	3.1	5.2	2.5	3.8	5.8	2.1	2.6	3.0	2.4	2.5	2.6	2.5
140x200	2.6	5.9	1.7	2.7	6.9	1.6	2.3	3.1	1.8	2.2	2.7	1.8
—200	20.5	85.5	2.8	19.1	83.1	2.7	40.6	91.5	4.7	42.7	92.7	5.0
Size distribution, wt pct												
+40-mesh	100.0	0.0	100.0	100.0	0.0	100.0	100.0	0.0	100.0	100.0	0.0	100.0
40x60	100.0	0.0	100.0	100.0	0.3	99.7	100.0	0.6	99.4	100.0	0.6	99.4
60x100	100.0	10.0	90.0	100.0	9.8	91.2	100.0	14.0	86.0	100.0	11.3	88.7
100x140	100.0	35.0	65.0	100.0	41.4	58.6	100.0	46.8	53.2	100.0	44.0	56.0
140x200	100.0	48.5	51.5	100.0	52.5	47.5	100.0	54.7	45.3	100.0	53.0	47.0
—200	100.0	89.3	10.7	100.0	88.8	11.2	100.0	93.2	6.8	100.0	93.3	6.7

tribution between underflow and overflow streams and ash analysis tests. This is due to the classification ratio phenomenon previously discussed and must occur with even the best hydraulic classifier. As a rule, the —100-mesh coal fraction represents a relatively small weight percent of the total coal, and this loss is considerably more than offset by the advantage of large slime reduction at the high capacity of the cyclone.

The ash analysis and distribution between underflow and overflow streams of Table I, Run 1 feed ash of 18.21 pct was reduced to 11.61 pct in the underflow with an overflow ash of 39.51 pct. Run 2, considerably more striking as feed ash, was 31.50 pct compared to 13.53 pct underflow and 61.97 pct overflow ash. Furthermore, almost all overflow ash is concentrated in the —200-mesh fraction with the coarser sizes being relatively pure coal. This may be expected from classification theory since the cyclone was set to discharge only high-ash slimes up to the 200-mesh point to the overflow in order to prevent serious loss of coarser coal. Sutherland[4] stated that the cyclone cleans only by removal of high-ash slimes when operating as a solid elimination or desliming unit. It is apparent that the mechanical and process advantages of elimination of the —200-mesh material is accompanied by a sizeable reduction in total ash content due entirely to the rejection of this fraction alone.

Hydraulic Water Additions

It is impossible to lower the weight distribution to the underflow of a nonconcentrated particle to less than the water split to the same stream for the cyclone under present methods of operation. However, if fresh water could be added, it might be possible partially to replace underflow slime water with new water and thus further reduce slime content. According to the theoretical and experimental work performed by Criner,[5] any fluid that reaches a certain vertical point with respect to cyclone underflow cannot reverse its path at the inner spiral but must be discharged through the underflow. The vertical distance of this point is furthermore hypothesized to be only the product of the linear distance between overflow and underflow times the fraction of total feed volume reporting to the underflow. Thus, it would seem logical to introduce fresh water slightly above this level.

To test hydraulic water possibilities, a ¼-in. pipe tangential entry with the same rotational direction as the feed nozzle was applied to the 20° cone. Location was 5¾ in. above the underflow, while vertical separation between underflow and overflow was 25½ in. Position of entry ports can be observed in Fig. 1. In the first set of runs, hydraulic water was held to less than 10 pct of the total water, while less than 8 pct of the water reported to the underflow with a solid concentration of greater than 50 pct as shown in Table II. Comparing Runs 3 and 5 with their counterparts, Runs 1 and 2, but without hydraulic water, results were found to be better in both cases. Run 5 exhibited a desliming coefficient of 0.87 (actually less than theoretical minimum, if no hydraulic water is used) compared with 1.27 for Run 2. Only 6.8 pct of the slime was retained in the underflow of Run 5, which compares favorably with 12.1 pct of Run 2. The slime percentage in Run 4 was reduced from a severe 40.6 pct in the feed down to 4.7 pct in the underflow product. Although desliming

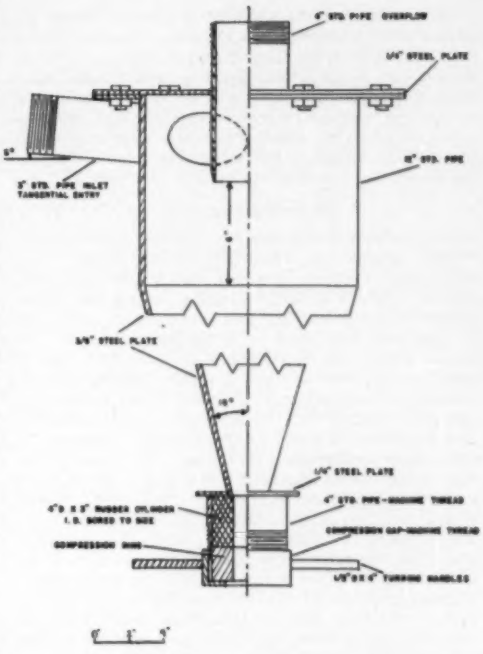

Fig. 2—Future experimental desliming cyclone with rapid adjust underflow.

coefficients are approximately the same for Runs 1 and 3 (1.41 and 1.39, respectively), the former retained 13.9 pct of the —200-mesh solids in the underflow compared with 10.7 pct for the latter. The comparison would have been considerably better if Run 1 had been performed at a higher feed rate, since it was only 58 pct of the value for Run 3. As previously indicated, the lower feed rate is conducive to better desliming, making a strict quantitative comparison between the two runs difficult. Again, an indication of desliming possibility of the cyclone is the reduction of —200-mesh in Run 3 from 20.5 pct in the feed to 2.8 pct for the underflow. Run 4 was conducted at exactly the same conditions as Run 3 to check reproducibility. Comparison of results indicates good duplication.

As shown in Tables I and II, there is a similar effect on the coarser sizes, which reported in appreciable quantities to the overflow. Slightly smaller percentages of these sizes were recovered in the underflows of Table II, which is to be expected from classification theory. However, as the loss is limited primarily to the —100-mesh coal, it may be offset by the value of greater slime rejection.

If the addition of hydraulic water is merely a dilution of the cyclone underflow solids followed by a concentration to a higher solid content, it would be advantageous for greater slime rejection to add the same quantity of water from a larger number of ports. An attempt to prove this was made by addition of a second nozzle only 4¾ in. above the underflow. The same quantity of water was then added in Run 6, Table II, as in Run 5, but evenly divided between the two ports. Comparison of results indi-

cates no significant advantage is present, since all factors are duplicated almost exactly. However, more thorough tests must be performed before a definite answer can be obtained. Such tests also must consider the important factors of entrance shape and location of hydraulic water ports plus input velocity and amount to be added. Probably, with maximum use of this addition, the desliming coefficient can approach very close to the perfect zero value.

Desliming Efficiency

In order to indicate qualitatively the effect of previously mentioned variables, several tests were performed, varying only one factor for each run. Runs 7, 8, and 9 of Table III were made to study the effects of solid loading and water splits. For the former variable, feed-solid concentration of the mixed solids was increased over Runs 2, 5, and 6 by approximately 100 pct without altering cyclone underflow diameter and other important design and operating factors. Run 7 was executed without addition of hydraulic water and should be compared for stability of performance with Run 2. It was indicated that heavy media and hindered settling effects were pronounced because of the high feed-solid content of 24.9 pct and an overloaded underflow discharge. The effect of the latter factor, which can be eliminated by an adjustable underflow nozzle, will be discussed under Run 9. Because of these phenomena, large percentages of 40x100-mesh material were lost in the overflow, but the desliming coefficient was reduced from 1.27 to 1.12. Only 11.9 pct of the —200-mesh fraction remained in the underflow with a solid concentration of 59.6 pct. However, it must be remembered that, while the desliming coefficient is improved by heavy solid loadings, higher percentages of water must accordingly be withdrawn in the underflow, resulting in approximately the same percentage removal of slimes as with the lower feed-solid concentrations.

Run 8 was similar to Run 7 with the exception of an addition of hydraulic water amounting to 9.4 pct of the total water entering the cyclone. Comparison of results with Run 5 indicates almost the same relationships as between Runs 7 and 2. The desliming coefficient was reduced to 0.74 with a retention of only 6.8 pct of total slimes in the underflow stream. When rejection of slimes was increased over Run 7, loss of the coarser sizes in the overflow was also slightly augmented.

To test the possibility of underflow overloading in the previous two runs and also show the disadvantage of high water splits to this stream, Run 9 was performed at similar conditions found in Run 8, but with an underflow water distribution of 36.1 pct. When the desliming coefficient remained the same for the two runs (0.74 and 0.76), 27.4 pct of the slimes reported to the underflow, having been carried there by the excess water directed to that effluent (underflow solid concentration was only 36.1 pct). This accents the necessity of retaining as high an underflow solid concentration as possible short of overloading.

Underflow overloading was present in Runs 7 and 8 since loss of +100-mesh material was considerably reduced in Run 9. This can be ascertained by comparing the lesser percentages of this fraction present in the overflow size analysis of Run 9 with the previous two runs. Apparently, the cyclone has a high degree of stability in handling varying solid loadings; but, if severe changes are to be expected, the cyclone must include an adjustable underflow.

From these results, the following conclusions may be drawn with respect to feed-solid concentration and its effect on cyclone design and installation:

(1) If solid concentration has a maximum of about 18 pct, one-stage cyclones should be used but so constructed that underflow diameter can be easily changed without shutdown in order to maintain a vortex discharge of optimum water concentration regardless of feed-solid loading. In this way, coarse coal losses can be held to a reasonable minimum. A suggested underflow design will be found in Fig. 2. It should be emphasized that underflow diameter changes will not occur often, since severe solid loading changes generally occur over long intervals. Probably, two to three simple adjustments per day will be maximum.

Table III. Effect of Feed Solid Loading and Water Split on Desliming Results, 9-in., 20° Cyclone

	Run 7, Mixed Solids			Run 8, Mixed Solids			Run 9, Mixed Solids		
	Feed	Overflow	Underflow	Feed	Overflow	Underflow	Feed	Overflow	Underflow
Nozzle diam, in.	2.067	2.5	0.75	2.067	2.5	0.75	2.067	2.5	1.0
Line pressure, lb per in.^{2}	2.13			1.94			1.87		
Volume rate, gpm	60.3	49.5	10.8	53.9	50.0	8.6	45.4	29.6	20.5
Water rate of slurry, gpm	50.0	44.7	5.3	45.5	43.8	4.6	38.5	27.6	15.6
Hydraulic water rate, gpm	0.0			4.7	(two inlet ports)		4.7	(two inlet ports)	
Solid rate, tons per hr	4.12	2.17	1.95	3.32	1.91	1.41	2.80	0.94	1.86
Solid concentrate, wt pct	24.9	16.28	59.6	22.6	14.3	55.1	22.5	11.96	32.3
Solid distribution, wt pct	100.0	52.7	47.3	100.0	57.4	42.6	100.0	33.6	66.4
Water distribution, wt pct	100.0	89.4	10.6	100.0	90.8	9.2	100.0	63.9	36.1
Hydraulic water, pct of total water	0.0			9.4			10.9		
Desliming coefficient	1.12			0.74			0.76		
Capacity ratio, K	5.37			5.63			4.48		
Screen analysis, U.S. standard, wt pct									
+20-mesh	6.3	trace	13.4	4.8	trace	11.3	7.3	0.0	11.0
20x40	24.2	2.9	47.9	24.1	2.5	53.2	28.2	0.3	42.3
40x60	14.6	11.4	18.2	14.7	11.4	19.0	15.7	3.5	21.9
60x100	7.3	8.6	5.8	7.2	8.4	5.5	7.1	7.8	6.8
100x140	2.5	3.0	2.0	2.6	3.1	1.8	2.2	3.9	1.4
140x200	2.4	2.7	2.0	2.3	2.5	2.1	2.1	4.0	1.2
—200	42.7	71.4	10.7	44.3	72.0	7.1	37.4	80.5	15.4
Size distribution, wt pct									
+20-mesh	100.0	0.0	100.0	100.0	0.0	100.0	100.0	0.0	100.0
20x40	100.0	6.3	93.7	100.0	6.0	94.0	100.0	0.4	99.6
40x60	100.0	41.0	59.0	100.0	44.7	55.3	100.0	7.3	92.5
60x100	100.0	62.3	37.7	100.0	67.3	32.7	100.0	36.7	63.3
100x140	100.0	62.4	37.6	100.0	69.8	30.2	100.0	58.5	41.5
140x200	100.0	60.0	40.0	100.0	61.6	38.4	100.0	62.8	37.2
—200	100.0	88.1	11.9	100.0	93.2	6.8	100.0	72.6	27.4

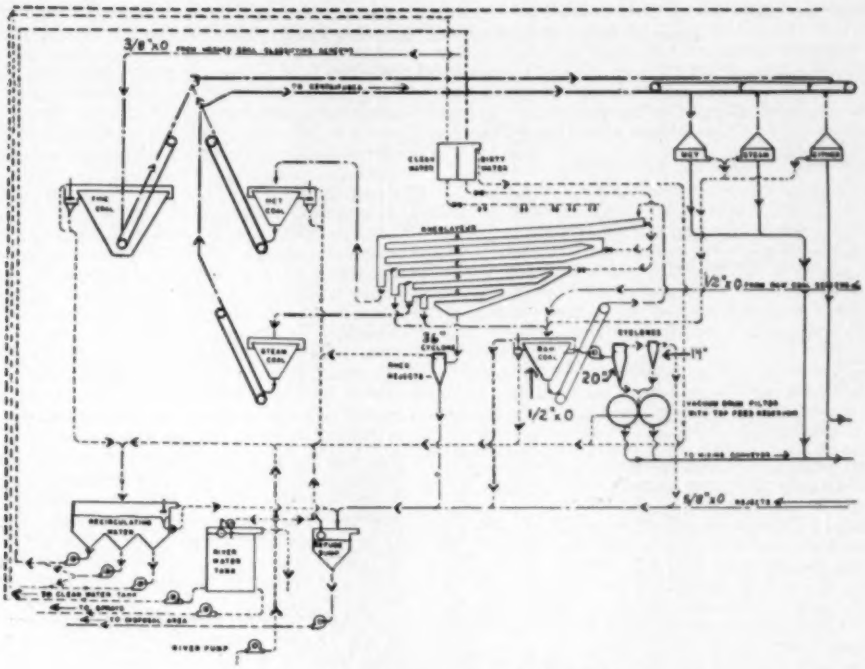

Fig. 3—Fine coal section with special cyclone desliming application.
From Sutherland

(2) When solid concentration exceeds 18 to 20 pct for appreciable time intervals, it might be most economical to install two-stage cyclones. By this means, one pump could be used to feed the first stage wherein the major portion of the coal would be withdrawn from the underflow at an optimum solid concentration. The overflow, still containing desirable material, would discharge directly to the second-stage cyclone under pressure wherein the final coal could be recovered at a similar underflow solid content. In this way, coal losses would be held to an economic minimum. Again, underflow flexibility would have to be built into both stages to permit running adjustments. This method has already been tried successfully by the Truax-Traer Coal Co. at Ceredo, W. Va.

Influence of Feed Rate and Nozzle Dimensions

Runs 10 and 11, Table IV, were performed at approximately double the feed rates of optimum Runs 2 and 5 on the same feed material. According to earlier work and eq 1, a lower 50 pct point would be predicted accompanied by a greater recovery of slimes in the underflow. Run 10 confirmed these expectations, as the desliming coefficient was 1.61 compared with only 1.27 for Run 2. As further proof of this, it will be noted that considerably higher recovery percentages of size fractions above the 200-mesh point formerly reporting to both product streams were experienced in the underflow of Run 10. Hydraulic water amounting to 7.5 pct of total feed water to the cyclone was applied to Run 11, resulting in an expected decrease of the desliming coefficient to 1.29. Slime retention, however, is still greater than that of comparable Run 5 at a lower feed rate, indicating again the higher concentrating effect of larger feed rates. In Run 11, 11.7 pct of the slimes remained in the underflow, which amounted to 7.3 pct of the total solids present in this stream, while Run 5 values were 6.8 pct and 4.7 pct, respectively. Recovery of the +200-mesh fraction in the underflow of Run 11 was quite similar to that of Run 10.

It may be concluded from the above observations that increase in slime retention of the underflow at the higher rate was only relatively slight, even though large increases in the 60x200-mesh fraction were experienced. This must be attributed to the large percentage of very fine clays and silts in the —200-mesh slimes with a correspondingly small percentage of near 200-mesh particles. If the latter material had been large, desliming efficiency would have been more severely injured in Runs 10 and 11. Thus, in order to operate at the maximum possible capacity, quantitative knowledge of the size consist of the —200-mesh fraction is a necessity. The finer the slime, the greater the capacity and the less the loss of +200-mesh coal to the overflow for any set of cyclone dimensions.

Influence of inlet and overflow nozzle dimensions was observed in the tests indicated in Table V. Conditions were maintained similar to optimum Run 5 but with the overflow nozzle reduced from 2.5 to 1.625 in. in diam. As would be predicted by eq 1,

Table IV. Effect of Feed Rate on Desliming Results, 9 in., 20° Cone

	Run 10, Mixed Solids			Run 11, Mixed Solids		
	Feed	Overflow	Underflow	Feed	Overflow	Underflow
Nozzle diam, in.	2.067	2.5	1.0	2.067	2.5	1.0
Volume rate, gpm	110.6	94.0	16.6	106.7	97.5	17.0
Water rate of slurry, gpm	98.2	89.7	8.5	98.7	85.0	9.45
Hydraulic water rate, gpm	0.0			7.8	(two inlet ports)	
Solid rate, tons per hr	4.51	1.63	2.88	4.19	1.51	2.68
Solid concentrate, wt pct	15.52	6.79	57.6	14.80	6.00	52.5
Solid distribution, wt pct	100.0	36.2	63.8	100.0	36.1	63.9
Water distribution, wt pct	100.0	91.35	8.65	100.0	90.95	9.05
Hydraulic water, pct of total water	0.0			7.5		
Desliming coefficient	1.61			1.29		
Screen analysis, U.S. standard, wt pct						
+60-mesh	47.4	trace	74.3	49.2	trace	77.0
60x100	6.7	0.3	10.4	6.6	0.2	10.3
100x140	2.5	0.2	3.7	2.3	0.4	3.2
140x200	2.1	1.3	2.6	2.0	1.6	2.3
—200	41.3	98.1	9.0	40.0	97.8	7.3
Size distribution, wt pct						
+60-mesh	100.0	0.0	100.0	100.0	0.0	100.0
60x100	100.0	1.6	98.4	100.0	1.1	98.9
100x140	100.0	4.5	95.5	100.0	6.4	93.6
140x200	100.0	22.0	78.0	100.0	29.2	70.8
—200	100.0	86.1	13.9	100.0	88.3	11.7

higher underflow recoveries were experienced in all size fractions reporting to both streams. This was especially significant in the 60x140-mesh sizes. Retention of slimes in the underflow exhibited a smaller increase as the desliming coefficient was 1.18 for Run 12 as compared with 0.87 for Run 5. Furthermore, 11.1 pct of the slimes was retained in the former case, while only 6.8 pct remained in the latter. The increase would have been more severe with a coarser slime.

The inlet diameter was next changed from 2.067 to 1.25 in. in Run 13 with the overflow still at 1.625 in. At an inlet equal to that of Run 13, an even greater increase in slime retention occurred. The desliming coefficient rose significantly from 1.18 to 1.73, while practically nothing above 200-mesh reported to the overflow. The importance of the size consist of the slime is again apparent as the recovery of this fraction in the underflow actually only increased to 14.2 pct.

To demonstrate further the significance of this factor, Run 14 was performed on the Burning Star solids with smaller nozzles and higher rates than Run 1 on the same material. The desliming coefficient increased very sharply from 1.41 to 2.76 with practically nothing above 200-mesh reporting to the overflow. The run may also be compared with Run 13 as approximately the same 50 pct point would be predicted from eq 1 for both tests under the conditions of operation. Because of the coarser nature of the Burning Star slimes, a considerably higher retention of this fraction (26.2 pct) was experienced in Run 14 than with the finer slimes of Run 13 (14.2 pct). Thus, it should be re-emphasized that larger nozzles and lower feed rates are necessary with the coarser slimes.

Influence of Included Angle

Earlier studies indicated that the 50 pct point increased with an increase in cyclone included angle.[4] Accordingly, for maximum solid elimination, it is necessary to maintain included angle at the minimum permitted by economic and headroom considerations. For a classification operation, such as desliming, this factor is negated by the desire actually to discharge material in the cyclone overflow. In-

Table V. Effect of Nozzle Dimensions on Desliming Results, 9 in., 20° Cyclone

	Run 12, Mixed Solids			Run 13, Mixed Solids			Run 14, Burning Star Solids		
	Feed	Overflow	Underflow	Feed	Overflow	Underflow	Feed	Overflow	Underflow
Nozzle diam, in.	2.067	1.625	0.75	1.25	1.625	0.75	1.75	2.0	1.0
Line pressure, lb per in.²	4.88			12.0			13.5		
Volume rate, gpm	59.3	54.4	9.6	59.7	55.1	9.3	100.6	84.1	16.5
Water rate of slurry, gpm	53.7	52.9	5.5	54.3	54.1	4.85	91.3	83.6	8.7
Hydraulic water rate, gpm	4.7	(two inlet ports)		4.7	(two inlet ports)		6.0		
Solid rate, tons per hr	2.34	0.90	1.44	2.22	0.65	1.57	3.31	0.53	2.78
Solid concentrate, wt pct	14.3	5.70	51.2	14.06	4.59	56.5	12.66	2.72	56.2
Solid distribution, wt pct	100.0	35.7	64.3	100.0	29.2	70.8	100.0	16.1	83.9
Water distribution, wt pct	100.0	90.6	9.4	100.0	91.8	8.2	100.0	90.5	9.5
Hydraulic water, pct of total water	8.1			8.0			0.0		
Desliming coefficient	1.18			1.73			2.76		
Capacity ratio, K	5.65			5.65			5.17		
Screen analysis, U.S. standard, wt pct									
+60-mesh	50.6	trace	78.8				60.9	0.0	72.6
60x100	6.9	0.5	10.4				10.0	trace	11.9
100x140	2.1	1.2	2.6				3.7	0.2	4.4
+140				64.8	trace	91.5			
140x200	2.2	3.3	1.6	1.4	0.5	1.7	3.7	0.4	4.3
—200	38.2	95.0	6.6	33.8	99.5	6.8	21.7	99.4	6.8
Size distribution, wt pct									
+60-mesh	100.0	0.0	100.0				100.0	0.0	100.0
60x100	100.0	2.6	97.4				100.0	0.0	100.0
100x140	100.0	20.4	79.6				100.0	0.9	99.1
+140				100.0	0.0	100.0			
140x200	100.0	53.4	46.6	100.0	10.8	89.2	100.0	1.8	98.2
—200	100.0	88.9	11.1	100.0	85.8	14.2	100.0	73.8	26.2

stead, greater importance can be attached to maximum capacity per square foot of floor space. Theoretically, it would appear feasible to adopt larger included angles and thereby step up feed rates to obtain suitable desliming efficiency. To test this possibility, a 30° included angle cone was substituted for the 20° section used in all previous tests. Vertical distance between overflow and underflow points was 16 in. Three ¼-in. nipples were applied tangentially to the cone for entry of hydraulic water and spaced 4, 3, and 1½ in. from the underflow. Runs 15 and 16, Table VI, were then executed on the mixed material along with the indicated amounts of hydraulic water.

Results of Run 15 at slightly higher feed rates than similar Runs 5 and 6 made on the 20° cone indicated desliming efficiency to be appreciably better for the larger included angle as predicted. Desliming coefficient was 0.76 as compared with 0.87 and 0.96 for Runs 5 and 6. Furthermore the percentage of hydraulic water used in Run 15 was almost 50 pct of that for the earlier runs. Actual retention of slimes was still higher than necessary, however, because of too dilute underflow slurry. The 30° cone had a fixed underflow designed for higher operation rates and thus at this lower capacity allowed too much water to pass to the underflow.

While desliming efficiency was better, excess loss of coarser coal was evident in Run 15. This was probably due largely to (1) the high-feed solid concentration (19.95 pct) causing "hindered settling effects" as previously indicated and (2) too low an inlet velocity or capacity for the 30° cone, which has been proved to yield a higher 50 pct point at the same rate than a smaller included angle cyclone. Therefore, Run 16 was conducted with a normal feed concentration of 14.4 pct and a 20 pct increase in rate. Desliming coefficient was reduced to only 0.70, although this was probably due to the higher percentage of hydraulic water used over Run 15. Slime concentration dropped from 31.5 pct in the feed to only 3.8 pct in the product with a retention of 8.1 pct of the total slimes. Rejection of slimes would have been even better if the underflow diameter had been adjustable since product dilution was too great. Loss of coarser coal to the overflow was decreased although still appreciably larger than with the 20° cone of Runs 5 and 6. Thus, it appears that still higher capacities with good desliming efficiency can be used on the 30° cone, probably in the neighborhood of 175 to 200 pct of that with the 20° cone. The capacity advantage of the larger included angle cyclone for desliming is evident.

Industrial Correlations

Correlation of the above work with industrial data is made very difficult by the lack of such information upon actual desliming processes at the 200-mesh point. There is only one coal operation of which the author is aware being conducted on cyclones with the specific intent of rejecting all —200-mesh material possible to the overflow. Furthermore, literature data on other desliming methods on coal slurries are nonexistent.

The pilot plant operation at the Ceredo, W. Va., tipple of the Truax-Traer Coal Co. has been desliming a feed stream obtained from high levels within the raw coal cones by use of a 14-in. cyclone. A detailed discussion will be found in Sutherland's paper,[9] from which Table VII has been obtained, to illustrate cyclone performance. It will be observed that the desliming coefficients are relatively good (1.075-1.61) even though capacities are approximately three times that used on the 9-in. 20° cyclone, with comparable nozzle dimensions. The maintained desliming coefficient at the higher rates was caused by two important factors pointed out in the previous experimental work. First, Sutherland indicated that underflow solid concentration was too high, resulting in a transition to overloaded type of underflow discharge as shown in Table VII, where underflow solid concentration ranged from 55.2 pct to 60.4 pct, while a vortex discharge on this type of coal requires a 50 pct concentration. Thus, while desliming efficiency was increased through this method, it was attained with an excess loss of coarse coal to the overflow nozzle, also pointed out by Sutherland. Secondly, the slime ash content in the feed stream was generally only 30 pct, indicative of a much lighter specific gravity material than with the high-ash slimes used on the 9-in. cyclone. This also yields

Table VI. Effect of 9 in., 30° Cyclone Included Angle on Desliming Results

	Run 15, Mixed Solids			Run 16, Mixed Solids		
	Feed	Overflow	Underflow	Feed	Overflow	Underflow
Nozzle diam, in.	2.067	2.5	0.5	2.067	2.5	0.5
Line pressure, lb per in.²	3.13			4.88		
Volume rate, gpm	56.5	43.5	13.0	68.3	61.3	13.0
Water rate of slurry, gpm	48.8	44.2	7.6	61.8	60.0	7.85
Hydraulic water rate, gpm	3.0	(three inlet ports)		6.0	(three inlet ports)	
Solid rate, tons per hr	2.95	1.04	1.90	2.94	0.88	1.76
Solid concentrate, wt pct	19.95	8.57	49.9	14.40	5.52	47.4
Ash, wt pct of solids						
Solid distribution, wt pct	100.0	35.4	64.6	100.0	33.3	66.8
Ash distribution, wt pct						
Water distribution, wt pct	100.0	85.3	14.7	100.0	88.4	11.6
Hydraulic water, pct of total water	5.8			8.85		
Desliming coefficient	0.76			0.70		
Capacity ratio, K	4.19			4.42		
Screen analysis, U.S. standard, wt pct						
+40	41.4	trace	64.1	43.9	trace	65.7
40x60	14.5	2.0	21.3	14.2	0.7	21.0
60x100	6.6	7.0	6.3	6.6	4.9	7.4
100x140	2.2	4.3	1.0	1.7	3.3	0.9
140x200	1.6	2.1	1.2	2.1	3.8	1.3
—200	33.5	83.6	0.1	31.5	87.3	3.8
Size distribution, wt pct						
+40	100.0	0.0	100.0	100.0	0.0	100.0
40x60	100.0	4.9	95.1	100.0	1.6	98.4
60x100	100.0	37.9	62.9	100.0	24.8	75.2
100x140	100.0	70.2	29.8	100.0	64.5	35.5
140x200	100.0	59.6	40.4	100.0	61.2	38.8
—200	100.0	88.9	11.1	100.0	91.9	8.1

a lower settling velocity particle just as decreasing particle diameter. Accordingly, a further generality can be made that the lower the specific gravity of the slime, the higher the feed rate for a desliming operation.

As a corollary on the effect of solid loading on desliming efficiency, it will be observed that the desliming coefficient for the 4-ft level run was very close (1.075) to the theoretical minimum value of 1.0. Feed concentration was also 19.6 pct, the highest of the three runs and definitely caused "hindered settling" conditions. While desliming thus was increased by heavy solid loading, loss of coarser coal to the overflow was increased simultaneously, as would be expected from the experimental work.

The first information on the recently completed two-stage cyclone installation at the Ceredo plant based upon results of pilot plant operation were made available by Robert Piros, engineer for the Truax-Traer Coal Co. This process, shown in the flowsheet of Fig. 3, consists of a raw coal cone feed from the upper level to two 20-in. cyclones. The underflow discharges to final dewatering, while the overflow passes under pressure to six 14-in. cyclones. Underflow in the latter cyclones also goes to final dewatering with the overflow reporting to refuse. The first stage is operated with only a 5-lb pressure drop between inlet and overflow compared with 26 lb for the second stage. Data will be found in Table VIII and are divided into three categories, observed and assumed data and resultant calculations. Flow rates are so high for the total unit that it is presently impossible to measure flow rates, thus necessitating the assumptions and estimations. The resultant calculations are accordingly subject to large discrepancies and, therefore, can be considered only as showing trends. Desliming coefficient for the high-pressure, 14-in. cyclone was 2.46, much poorer than 1.23 for the low-pressure drop 20-in. cyclone. As pressure drop is a measure of energy available to create a centrifugal field, the higher desliming coefficient for the 14-in. cyclone seems logical. Furthermore, such a result would be predicted by eq 1.

Desliming Capacities

An empirical equation based upon experimental work and industrial correlations for any cyclone operating with a vortex underflow has been advanced in a previous article.[4]

$$\frac{\text{Gpm}}{\sqrt{F}} = K\,(be)^{6.9} \qquad [2]$$

The proportionality constant is a function only of included angle, separation between overflow and conical section, and minor design deviations. Values of 5.48 and 4.82 were found for the 20° and 30° cones, respectively, used in these tests. Assuming eq 2 as valid, K values were calculated for the various runs as indicated in the tables. For the 20° cyclone, the K's were very consistent with the exception of Run 9. In this case, over 45 pct of the volume reported to the underflow, which undoubtedly resulted in a different flow pattern and also represents an industrially inoperable condition. Eliminating Run 9, average K for the 20° cone was 5.35, or only 2.4 pct below that for the higher pressure cyclone. Average value for the 30° cone on two runs was 4.31, or 10.6 pct deviation from the previous result. This small deviation is probably due to the increase in importance of wall friction when low centrifugal fields are used. If this latter force is high, practically all inlet energy is consumed in overcoming fluid friction to create a high rotational kinetic energy. It should be noted at this point that the K value of the 30° cone can be increased (and thus decrease energy requirements per gallon of slurry pumped) by separation of overflow and conical section. Previously it was demonstrated that by a separation of 6 in., K value of the 30° cone equaled or bettered the 20° cone value.[4]

Capacities per square foot of area for the desliming cyclone are extremely high when compared with the conventional classifiers. The 9-in. cyclone used in these tests yielded average rates on the mixed solids of 113 gpm of slurry per sq ft of area (exclusive of hydraulic water) for the 20° cone and 155 for the 30° cone. In the latter case, it is believed the value could have approached 220 gpm per sq ft of area without appreciable loss of desliming efficiency. Furthermore, in desliming operations, a larger percentage of the cyclone radius can be occupied by the overflow and inlet nozzles without injuring desliming efficiency, thereby increasing capacity per square foot of area. It will be observed that the proposed 12-in. desliming cyclone of Fig. 2 for future experimental work has inlet and overflow nozzles of 3 and 4-in. standard pipe, respectively. Thus, inlet and overflow nozzles consume 85 pct of the cyclone radius. For this cyclone, 200 to 235 gpm feed rate is predicted, operating on slimes of the mixed solid type used in these studies. This would offer a capacity of 250 to 300 gpm per sq ft of area for conventional methods. Actual rates for any slime will, of course, depend on the size and specific gravity of the −200-mesh fraction.

Desliming Applications

Results from the experimental work reviewed indicate that the cyclone may be applied to any desliming operation wherein up to 85 to 95 pct of the −200-mesh fraction must be removed from the coarser coal. Furthermore, this is accomplished with extremely high capacities per square foot of area, very low initial and operating expense due to the simple construction and absence of moving parts, and delivers a partially dewatered product ready for final mechanical drying.

Referring to Fig. 4 as a general practical application, any process stream which should be deslimed before final dewatering would be fed first to a deslimer cyclone. Design, nozzle dimensions, feed rate, and amount of hydraulic water would be determined by methods indicated earlier. Underflow product containing 50 to 55 pct solids could then be dewatered mechanically by use of rotary vacuum filters, continuous screen-type centrifuges, or solid bowl centrifuges. Since the underflow product is relatively fine, thus containing a high moisture content, it either would be blended back into coarser coals, if moisture restrictions permitted, or the less desirable operation of thermal drying would have to be performed.

Overflow from the deslimer, rich in unwanted fines, could follow two alternate paths. Where makeup and disposal of water is not a problem from both an economic and scarcity standpoint, the overflow can be discharged directly to waste. If a partially or fully closed water system is desired, the overflow should be processed in highly efficient cyclones to recover as much of the slimes and fines

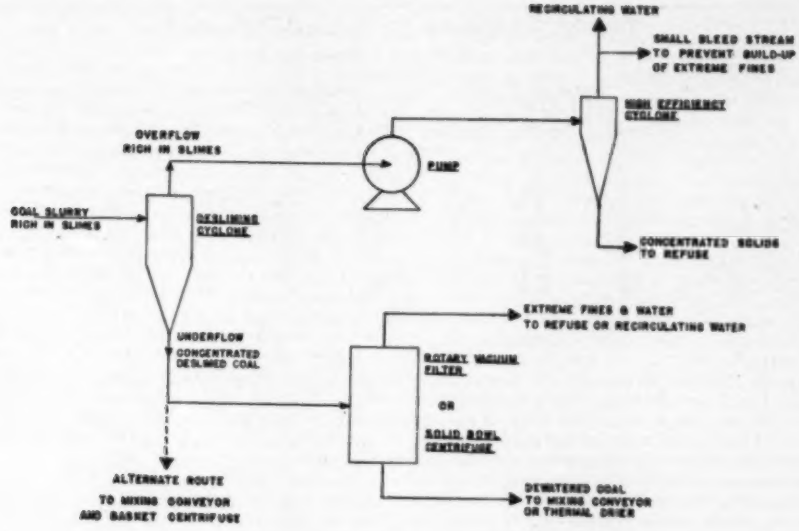
RECIRCULATING WATER
SMALL BLEED STREAM TO PREVENT BUILD-UP OF EXTREME FINES
HIGH EFFICIENCY CYCLONE
OVERFLOW RICH IN SLIMES
PUMP
COAL SLURRY RICH IN SLIMES
DESLIMING CYCLONE
CONCENTRATED SOLIDS TO REFUSE
EXTREME FINES & WATER TO REFUSE OR RECIRCULATING WATER
UNDERFLOW CONCENTRATED DESLIMED COAL
ROTARY VACUUM FILTER
OR
SOLID BOWL CENTRIFUGE
ALTERNATE ROUTE TO MIXING CONVEYOR AND BASKET CENTRIFUGE
DEWATERED COAL TO MIXING CONVEYOR OR THERMAL DRIER

Fig. 4—Suggested flowsheet, desliming fine coal partially closed water system.

in a concentrated form as reasonably possible, which would then be directed to waste. Methods for designing this type of cyclone were covered in earlier articles.[2, 4, 6, 7] The overflow from the secondary cyclones would be returned to the recirculating plant water with the exception of a relatively small bleed stream sent to waste to prevent buildup of extreme fines below 10 to 15 microns not adequately removed by the cyclone. This latter feature has been thoroughly discussed in the paper of Criner and Driessen, which illustrates flowsheet calculations.[5]

Future work may prove it possible to combine the cyclones of Fig. 4 into a two-stage process, eliminating the secondary pump. At present, insufficient data are available to predict resultant efficiencies for cyclones operating with an overflow back-pressure. A notable step has been made in this direction by the Truax-Traer Coal Co. in the desliming of a portion of its fine coal by drawing from high levels within the raw coal cones and feeding the slurry to desliming cyclones. In this manner, it has been possible to bypass the launder cleaning of these fines and also recover a sizeable amount of formerly wasted coal. The process has been discussed in the paper by Sutherland from which the flowsheet of Fig. 3 was taken.[4]

The possible application of the cyclone to other similar recovery programs wherein a saleable product can be recovered from a waste stream or material with relatively little expenditure must be emphasized. In light of recent developments, the author advises individual examination of all waste slurries and products to determine ash and coal concentration as a function of particle size. Many instances where slime removal from a refuse material might result in a marketable item may occur.

Optimum cyclone design for a desliming operation should include adjustable underflow diameter and maximum capacity per square foot of area. Fig. 4 pictures one design which fulfills these requirements and is now being constructed for future work at Northwestern University. The largest possible inlet and overflow diameters that can be accommodated by the cyclone radius without interference have been used. The large included angle and 6-in. separation between overflow and conical section will yield maximum capacity as previously indicated. Underflow nozzle consists of a rubber cylinder with a concentric hole bored to size. Through the cyclone design, the rubber can be compressed from three sides causing the passageway to converge at the center. Adjustment can be made speedily while the cyclone is in operation. Finally, hydraulic water ports can be added as required near the apex of the conical section. Work is now in progress to facilitate prediction of optimum entry shape, location, and fluid velocities for this particular cyclone.

Final Mechanical Dewatering Methods

As the deslimed cyclone underflow material is delivered at about 50 pct solid concentration, final means of dewatering to a reasonable moisture content are necessary. Three methods are probably most advantageous at the present writing: (1) continuous screen-type centrifuges, (2) solid bowl centrifuges, and (3) rotary vacuum filters.

The first process undoubtedly offers the cheapest initial and operating cost per ton of solids processed per hour. In operation, cyclone underflow would have to be blended with a coarser coal and fed to the centrifuges in order to prevent the loss of too much material through the screens. Furthermore, moisture content of the underflow stream is too high to permit a direct feed. Solid capacities of such units are high and thus in some instances, where unused capacity is available, new purchases may not be necessary. Several disadvantages of this method should also be indicated. The screen-type centrifuge

Table VII. Industrial 9-in., 20° Cyclone Desliming Results

Truax-Traer Coal Co., Coredo, W. Va.

	Feed from 2-Ft Level of Raw Coal Cone			Feed from 3-Ft Level of Raw Coal Cone			Feed from 4-Ft Level of Raw Coal Cone		
	Feed	Overflow	Underflow	Feed	Overflow	Underflow	Feed	Overflow	Underflow
Nozzle diam, in.	2	2		2	2		2	2	
Pressure, lb per in.²	39			39			39		
Volume rate, gpm	191	159.5	31.5	196	166.6	29.4	195	154.9	40.1
Solid rate, tons per hr	7.67	2.72	4.95	7.81	2.64	5.47	10.21	2.66	7.55
Water rate, gpm	170.0	154.0	16.0	176.3	150.9	16.4	168.1	148.3	19.8
Solid concentrate, wt pct	15.3	6.6	55.2	15.2	6.2	57.1	19.6	6.7	60.4
Ash, wt pct of solids	10.91	18.42	6.76	11.52	19.91	7.23	9.40	17.45	6.59
—200-mesh, wt pct of solids	32.7	81.8	5.8	31.6	79.6	7.2	22.7	76.4	3.8
Solid distribution, wt pct	100	35.5	64.5	100	33.6	66.2	100	26.1	73.9
Water distribution, wt pct	100	90.5	9.5	100	90.7	9.3	100	88.2	11.8
—200-mesh distribution, wt pct	100	88.6	11.4	100	85.0	15.0	100	87.3	12.7
Desliming coefficient	1.20			1.61			1.075		

passes appreciable solids through its perforations (usually 1/16-in. round hole), which must be discarded or returned to process. The latter naturally results in a build-up of fines in the system which, coupled with the other disadvantages to follow, may lead to an aggravated condition. This type of centrifuge has an appreciable degradation factor on the coarse sizes, which causes further loss of coal and creation of slimes. Finally, the blending back of a relatively fine, wet stream with the coarser coal is known to increase severely the moisture content of the resultant product as the dewatering ability on the very fine sizes is seriously lowered. The generalization can be made that basket centrifuges become more desirable as the particle size of the deslimed coal increases.

The solid bowl centrifuge operation and results have been discussed by Lyons and Richardson.[10] The conclusions are drawn that final moisture content will be a function of percentage of −150-mesh material and water content of the centrifuge feed. A decrease in either factor will be advantageous toward a drier cake product. Dewatering capacities are very high for this difficult size, which is its prime advantage. Final moisture content is probably equal to any other method. Disadvantages seem to lie in product degradation, high initial cost, and the possible large maintenance expense due to the wearing of expensive parts.

The final method employs a rotary vacuum filter which, like the solid bowl centrifuge, is a relatively recent innovation in fine coal water elimination. Flotation concentrates have been dewatered by this process for some time, but with coarser coals, special feed methods are necessary to permit suitable formation of a filter cake. Sutherland's paper reports on the Peterson top feed reservoir rotary filter, which is gaining wider acceptance in the coal industry. Pilot-plant operations on a deslimed fine coal indicated that capacities would vary between the extremes of 6 to 39 tons of dry solids per hr per 100 sq ft of filter surface with different operating conditions. A general average of 15 to 20 tons of dry solids per hr per 100 sq ft of filter surface appears logical in this case under normal operation on a 16-mesh, top-size coal. According to Sutherland and Piros, dewatering ability will be primarily a function of feed rate and volume of air passing

Table VIII. Industrial Cyclone Desliming Results on Fine Coal Flow Circuit

Truax-Traer Coal Co., Coredo, W. Va.

	20 In. Feed	20 In. Underflow	20 In. Overflow, 14 In. Feed	14 In. Overflow	14 In. Underflow
			Observed Data		
Pressure, lb per in.²	31.0	0.0	26.0	0.0	0.0
Solid concentrate, wt pct		48.6		5.83	54.0
Screen analysis, wt pct					
+14-mesh		3.1			
14x30		34.4			3.8
30x50		38.9		0.2	40.0
50x100		12.4		6.4	34.0
100x200		4.4		15.5	11.6
—200		6.8		77.9	10.6
Ash content, wt pct					
Total solid					
—200-mesh		8.25		15.04	7.87
Solid rate, tons per hr		30.63		18.73	32.07
Estimated vol. rate, gpm	1800				21.0
				1500	
			Assumptions		
Bulk, sp gr		1.17		1.02	1.18
			Resultant Calculations		
Volume rate, gpm	1800	170	1630	1500	130
Water rate, gpm	1611	162	1509	1440	69
Solid rate, tons per hr	67.5	34.2	43.3	22.3	21.0
Solid concentrate, wt pct	13.13	48.6	10.3	5.83	54.0
Water distribution, wt pct	100	6.3	93.7/100	95.4	4.6
—200-mesh distribution, wt pct	100	7.75	92.25/100	88.7	11.3
Desliming coefficient		1.23			2.48

through a unit thickness of cake. Another factor is undoubtedly size distribution, although this was found to be of less importance than predicted by previous literature on other dewatering methods. Explanation for this deviation probably can be found in the low percentage of −200-mesh in the filter feed. Literature correlations are based primarily on the content of this fraction in the feed and thus a deslimed coal could be expected to exhibit higher and more consistent rates.

Advantages of this type of filter are the complete freedom from size degradation, delivery of a product comparable in moisture content with other methods at a good capacity, high solid recovery, and low maintenance costs due to elimination of abrasive contacts. Filtrate may also be returned to the circulating water as no further slimes have been created through degradation. Disadvantages are high installation costs (about equal to the solid bowl centrifuge per ton of solid per hour) and lesser capacity per square foot of floor space than the screen-type centrifuge.

Summary and Conclusions

Experimental work has indicated that desliming or classification up to the 200-mesh point with the cyclone is not only possible but, because of the following factors, is extremely successful. Initial and operating costs of the cyclone are known to be very small because of the simplicity of design and lack of moving parts. This is especially true with the deslimer as pressures below 10 lb are used. Up to 90 to 95 pct of the slimes can be eliminated through correct cyclone construction and operation. Recovery of +100-mesh coal will be very close to 100 pct in a partially dewatered state. Cyclone operation is relatively stable even with changing feed solid concentration. If underflow flexibility is included in the design, very severe feed loading alterations can be handled. Cyclone capacities of up to 300 gal per hr per sq ft of floor space are very high when compared with the conventional values of 1 to 2 gpm per sq ft. Finally, the deslimed coal (much of which may have been wasted formerly) is of a size distribution which will exhibit reasonable, final, mechanical dewatering rates.

Although rigorous research now in progress using pure solids must be completed before exact predictions of cyclone design and feed rates can be made, eq 1 with proper safety factors affords reasonably close estimates of these values in the interim. The calculation method indicated earlier in the paper will suffice for a 20° cyclone processing a relatively coarse slime similar to the Burning Star solids. Feed rate on finer silts and clays may be increased 10 pct to 25 pct, while 30° cone capacities can be almost doubled. Energy requirements for a desliming cyclone can be predicted from eq 2 using K values approximately 95 pct of those for ordinary high pressure units. In order to gain maximum capacity, a 6-in. spacer between overflow and conical section is recommended.

The feasibility of introducing small amounts of fresh water to further reduce slime elimination has also been proved. In these tests, hydraulic water amounting to 5 to 10 pct of the total water to the cyclone resulted in a decrease of approximately 40 to 50 pct in the amount of slimes retained by the underflow product. As this innovation was originated during the tests, no precise statements as to optimum entry design and location or amounts and input velocities can be made at this time. Qualitatively, it may be stated that entry location should be at the apex of the conical section and removed from the underflow approximately by the distance obtained from multiplication of the fraction of total volume to the underflow times the vertical distance between underflow and overflow nozzles. Furthermore, inlet velocity and probably volume rate of hydraulic water must be decreased as distance from the underflow is decreased.

Prolonged feed-solid concentrations over 18 pct should be avoided for a one-stage cyclone to prevent loss of coarse coal. Methods for handling such conditions have been discussed and usually result in a two-stage flowsheet. To put the deslimer cyclone "on stream" and for running adjustments in case of severe changes in solid loading, the design should permit easy alteration of underflow diameter. One simple construction method is indicated in Fig. 2.

Possible desliming applications have been advanced together with typical flowsheets. Water recovery can be combined with this operation by use of high elimination-efficiency cyclones as indicated. Lastly, various methods of final mechanical dewatering were discussed so that entire process considerations can be accomplished.

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The Graphite of the Passau Area, Bavaria

by Russell G. Wayland

SINCE the installation at Kropfmuehl, Bavaria, of a modern flotation concentrator in 1938, the flake and fine graphite from the Passau area can now be delivered in about any normal specified carbon content of any size range up to a flake averaging about 0.7 mm. The graphite finds a wide German and export market for crucible manufacture, pencil leads, dry cells and other uses.

A controversy over the origin of the graphite deposits is being resolved in favor of syngenesis rather than epigenesis. The syngenetic theory is newly supported by the yet unpublished work of Hartmann of the Bavarian Geological Survey. Development work and exploration for graphite in the area may be changed in direction as the syngenetic theory is accepted.

Crystalline graphite is produced in the area east of Passau near the junction of Germany, Austria and Czechoslovakia, as shown in Fig. 1. This is the only graphite area of importance in Germany, and Graphitwerk Kropfmuehl AG is the only operating firm in the area. The plant and mine are located at Kropfmuehl near Hauzenberg, Kreis Wegscheid, about 10 miles east of Passau. A narrow gage railway from the mine connects with the German Railway at Schaibing Bahnhof.

The Pfaffenreuth mines date from about 1730. Until the early 20th century mining operations were carried out in a haphazard fashion. During World War I graphite mining and milling was increased, since it had to cover almost all of the crucible needs of the Central Powers. Between the wars some 11 mines were operated by two large and several small companies, but under the Nazis these were consolidated by 1938 into the Kropfmuehl enterprise. Kropfmuehl built a modern flotation mill to treat its own ores and small amounts of custom ores and tailings from the area. Since Graphitwerk Kropfmuehl AG was an I.G. Farbenindustry subsidiary, it has been under Military Government Property Control and probably will be sold to private German capital.

Geology

The country rock of the graphite area is part of the "kristallines Grundgebirge," the series of old gneissic and schistose rocks that constitutes the bed rock of most of the Bohemian basin and rims the Sudetenland. The gneissic rocks of the graphite area are considered to have been metamorphosed during the Carboniferous period. They are bordered on the north by granite stocks and penetrated by numerous smaller granite and pegmatitic intrusive rocks, as shown in Fig. 1. The gneiss is classed as a micaceous, coarse-grained cordierite gneiss by most investigators. It is much metamorphosed by the granite, particularly in the north near the larger granite bodies. Interbedded in the gneiss are the graphite seams and lenses, and also beds and lenses of crystalline limestone containing disseminated graphite in noncommercial quantities.

The gneiss, together with the included graphite and limestone seams and lenses, is cut and displaced by a number of granite sills of medium to fine grain and by a large number of diorite lamprophyre dikes and a few syenite-pegmatite dikes. The lamprophyre dikes are of various mineral compositions and textures, but many are banded and richly impregnated with pyrite; while the syenite-pegmatite dikes are coarse-grained with good crystals of titanite, pyroxene, uralite and other green amphiboles. Most investigators and the miners speak only of diorite and granite dikes cutting the graphite seams. The diorite dikes are later than the granite and some of the faulting, as is evident from Figs. 1 and 2.

Individual graphite seams and lenses may be mined for thicknesses of several feet up to several scores of feet, and for distances of several hundred feet. The aggregate thickness of a series of some 20 seams of graphite, limestone and interbedded gneiss at Kropfmuehl is stratigraphically about 450 ft. Laterally, the graphite in a seam may pinch out or grade into crystalline limestone. Graphite crystals also are found disseminated in the gneiss itself, although in unmineable concentrations. The faults that cut the graphite seams carry graphite for some feet or tens of feet away from the seams, apparently mechanically. Similarily, the graphite lenses themselves often contain mechanically introduced inclusions of wall rock, probably from flowage during folding.

Graphite crystals make up 10 to 30 pct of the fresh, mineable graphite lenses at Kropfmuehl, averaging about 20 to 25 pct after hand-sorting by the miners. In weathered lenses, the graphite concentration is said to be as high as 50 pct. The associated primary and hydrothermal minerals are dominantly feldspar and calcite, plus quartz, pyrrhotite, pyrite, biotite and occasional garnet, hornblende, sphalerite and galena. Associated secondary minerals include kaolin, nontronite, mangano-oxide-silicates (mog), adularia and chlorite. The superimposed suite of siliceous cementation minerals present consist largely of opal, chloropal, chalcedony, jasper, and hyalite. The kaolin is of special interest since it too was mined as early as 1730 and was used in the well-known Nymphenburg porcelain from 1756 on. The kaolin is derived from the gneiss and the syenite pegmatites.

The crystals of graphite vary in size within a given seam, but in seams more than a mile away from the granite on the north the average crystallinity is less coarse, lowering the commercial value. The lenses in the Kropfmuehl-Pfaffenreuth area are the most developed, and are the only ones with deep workings now accessible. Other similar crystalline graphite lenses are known from older workings at Habersdorf, Oberoetzdorf, Ficht, Diendorf, and

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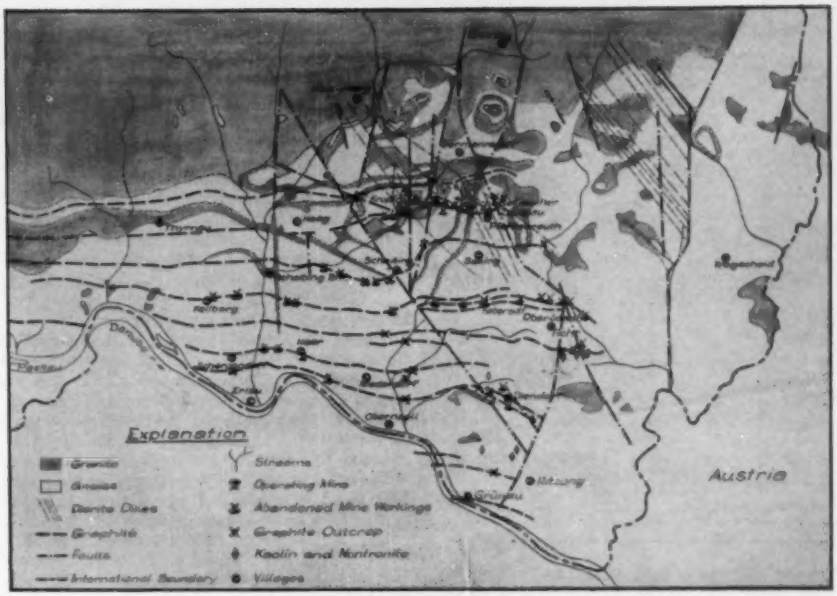

Fig. 1—The Passau graphite mining area.

Bedrock geology, after Hartmann, Bavarian Geological Survey.

Haselbach, while most of the other areas indicated on Fig. 1 await future development below the water table.

The graphite lenses and seams conform with the regional gneissic structure and follow the folding in the gneiss. The major structure in the immediate area of Kropfmuehl-Pfaffenreuth now has been shown, Fig. 2, by Hartmann to be an open syncline called the Zwingau syncline. Its axis strikes east-west, roughly parallel to the border of the granite stock to the north, and plunges gently to the west. The Zwingau saddle to the south is less well developed. Minor folding along these major structures is common. During the folding the graphite was squeezed within the original seams and also into cross fractures. The local reconcentration of graphite within a given seam has been noted to be thicker on the saddles of minor folds. Increased thickness of graphite lenses also has been correlated with the crosscutting diorite. Hartmann uses these two observations in suggesting future development work to the mine management.

Guembel,[1] the first to consider the origin of the graphite, concluded that it was syngenetic. But most German geologists since Weinschenk[2] have considered the graphite to be essentially epigenetic. Laubmann[3] summarized the development of this theory. He reasons that ascending gases and steam reacted with the gneiss, depositing graphite both by decomposition of carbon-bearing material already in the gneiss and by introduction of carbon from magmatic sources either as an unstable carbonate, a carbonyl, or a carbide. He notes that such chemical reactions to precipitate introduced carbon do not explain the apparent absence of most of the accompanying metallic ions, except in the case of the graphite crystals in the crystalline limestone where he reasons that the graphite was introduced as calcium carbide. Laubmann[3] merely mentions the possibility that the graphite might have originated in the metamorphism of richly bituminous sediments.

Hartmann is among those who consider the origin of the graphite to have been from coal or highly bituminous sediments. The shales and interbedded limestones were metamorphosed with the coal into the present rocks during the period of mountain building accompanied by the igneous activity. Subsequent hydrothermal alteration, including the kaolinization, was followed by low-temperature silicification and weathering processes.

Since the mine development in recent years has been based on the epigenetic theory, special attention has been paid to sections of the mine where it was reasoned that the graphite ascended to form replacement deposits. Acceptance of the syngenetic theory will probably redirect laterally the search for new graphite lenses.

Mining

In early mining, shafts were sunk as deep as 60 to 100 ft every 40 to 70 ft along the strike of an outcropping lens. The little underground development was by drifting and crosscutting, and workings were limited by the water table. The first modern mining was introduced shortly before World War I and extended during that war. Since the acquisition by Graphitwerk Kropfmuehl of nearly all graphite

Table I. Avg Analysis of High Quality Products, September 1948

	Crucible Flake		Best Pencil Grade
	S 40	NFL	AF
Carbon	94.5	93.0	96.2
Silica	2.22	3.98	1.63
Ferric oxide	1.35	1.41	0.93
Sulphur	0.33	0.39	0.22

Table II. Quarterly Graphite Statistics

Graphitwerk Kropfmuehl A.G.
Cleaned and Screened Graphite Concentrate.

Quarter	Year	Production, Metric Tons: Quarter	Production, Metric Tons: Pct of 1938[b]	Shipments, Metric Tons	Closing Stocks, Metric Tons
4	1945		0	N.A.	1576
1	1946	147[a]	22.9	884	839
2		829	43.1	993	675
3		1587	82.5	1214	1048
4		1222	63.5	1209	1061
1	1947	426	22.1	599	888
2		1478	76.8	1229	1139
3		1633	84.9	1739	1042
4		1393	72.4	1669	766
1	1948	1623	84.4	1776	613
2		1547	80.4	1771	389
3		1408	73.2	953	844
4		951	49.4	553	1342
1	1949	480	23.8	704	998
2		1613	83.7	967	1644
3		1269	65.9	1356	1556
4		1507	78.2	1302	1761
1	1950	1481	76.9	1471	1771
2		1181	61.3	1655	1297

[a] Production was in March only.
[b] Quarterly average for 1938 = 1925 tons.

properties, the old shafts and adits in the Kropfmuehl-Pfaffenreuth area have been connected partially with the deeper, newer workings. Three shafts are currently in use from the surface, and they have been supplemented by four blind shafts. The Kropfmuehl mine management recognizes 13 operating levels of which the sixth level, at 1310 ft elevation and 240 ft depth below the mill site, is the main haulage level at the west end of the mine. Workings extend 1.6 miles eastward from the 410-ft main shaft and have a lateral extent of as much as ¼ mile. The lowest level is the eighth at the west end at an elevation of 1120 ft, while at the Pfaffenreuth end an adit level is at 1900 ft elevation.

In the Kropfmuehl mine in 1946 there were 32 faces developed, of which 23 were being worked. The amount of graphite currently developed is enough to supply the mill for four years. The mining system is over-hand cut and fill. There are normally two miners per working face, and altogether about 200 men working underground. The blasted material is hand sorted at the face, with the waste going immediately to back-fill. Haulage on the main haulage level is by storage battery locomotive. The pumps handle 800 to 1000 gpm of water.

A new petrographic study of Landwehr[4] of the relative silicosis hazard in the rocks and ores of German mines shows that the Passau graphite ore and its dust are only about 25 pct as dangerous as the average highly siliceous rock.

Milling

According to Kausch,[3] the firm known as Gebr. Bessel (Bessel Bros.) was cleaning graphite in about 1880 by its own patented process (DRP 42). Milled graphite was mixed with 1 to 10 pct oil or fat, with or without carbon dioxide, and then boiled in water. The foam carried the graphite, while the feldspar, mica, and quartz sank. Among the reagents used were fusel oil, rubber, resin-like materials, benzine, paraffin, beeswax and ozokerite (?). To produce bubbles, they also tried about 1 pct of limestone and a little acid (DRP 39369).

By 1910, Bessel Bros. had added a process to clean the floated graphite. They screened it, mixed it with a fat (Arachis oil ?), and then worked it to a warm paste, added water and boiled it. The foam from this went to another mixer. Finally the oil was distilled off at 1100°C and the graphite again washed. The last concentrator using this process was built before World War I, and it enabled the mining and milling of fresh unweathered ores of lower grade than previously had been mined. Graphite recovery in 1908 in this mill was 734 metric tons of refined graphite or 15 pct of the crude ore mined. An additional 354 metric tons of low quality also were recovered.

Between the World Wars the concentration of Passau graphite was by a process still in use in southern Bohemia and recently described by Gruender.[5] After fine milling in the presence of normal flotation reagents and alkali, the graphite ore in a suspension about 8 pct solid was directed at 6 atm pressure onto the surface of the water in the middle of a large tank about 10 x 26 ft in size. The tank had a trough-like bottom where air bubbles entered and nongraphite minerals were drawn off. A graphite froth formed on the surface in the middle of the tank and moved to skimming points at both ends. Nongraphite minerals settled out of the froth as it moved over the more quiet parts of the tank toward the skimming points. In Bohemia the concentrate is reprocessed twice, which increases the concentration respectively from about 52 to 71 to 92 pct graphite, and the practice at Passau is understood to have been similar.

Beneficiation in the present Kropfmuehl mill (Fig. 3) is based on modern flotation cells which use both mechanical agitation and introduced air. The pulp is not introduced under pressure. The processing of the ore takes place in four distinct steps, crushing, concentrating, drying, and dry milling. In the crushing department a Krupp jaw crusher is followed by trommels, picking belt and a Symons cone crusher set to about ⅛ in. In the concentrator this material is taken from a bin and passes through a rod mill in closed circuit with a screw classifier which delivers all the ore at about 40-mesh to the 23 flotation cells. The graphite is floated from the pyrrhotite and pyrite, which constitute about 4 to 5 pct of the raw ore, and from other gangue and remilled three times. The flowsheet for concentrator operations in use in February 1946 is shown in Fig. 4. The flotation concentrate goes to a Dorr thickener and a drum filter. The drum filter, which delivers graphite with 20 pct moisture to the furnaces, is being replaced by a large centrifuge which delivers graphite with only 5 to 6 pct water, giving a substantial fuel saving. The dried furnace product aver-

Table III. Kropfmuehl Requirements

	Annual Requirements	Requirement per 100 Tons of Graphite Concentrate
Coke, tons	1100	18
Bituminous coal, tons	240	4
Lignite briquettes, tons	120	2
Diesel oil, gal	1600	26
Lubricants, tons	12	0.2
Dynamite, tons	18	0.3
Carbide, tons	9.6	0.16
Flotation reagents, tons	21	0.35
Drill steel, tons	8.4	0.14
Drill steel bits, No.	720	13
Pipe, ft	4000	66
Mine timber, cu m	840	14
Paper sacks, No.	120,000	2000

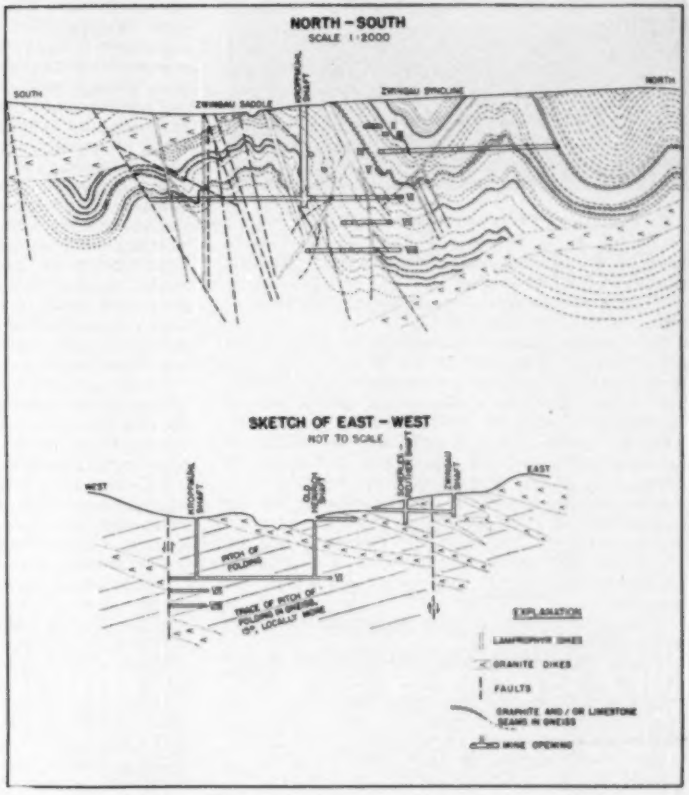

Fig. 2—Kropfmuehl structure sections. After E. Hartmann.

ages 88 to 92 pct carbon with the balance mainly silicates.

Passing through a dust collecting system, the dried graphite enters 10 batteries of vibrating screens ranging from coarse down to one that retains particles 0.015 mm in size. The screened fines go directly to bagging or are combined in mixers to meet customer specifications. Most screened fines are medium to low in grade, containing from about 90 pct down to as low as 75 pct carbon. Lower qualities down to 40 pct are produced on demand.

The flake graphite is milled and rescreened four times to increase its purity and to separate broken crystals. The seven Pallmann mills made in the Saar for this purpose are 4-ft diam granite disks, the top disk stationary, the under disk rotating at about 5 rps on a vertical axis. For customers like the pencil companies requiring a high-purity, very fine graphite powder, some flake graphite is pulverized in hammer mills. Laboratory control at all stages appears to be good. The average analyses of several of the better qualities of product in September 1948 are given in Table I. These qualities are also notably free of mica.

The Kropfmuehl mill gets about 94 pct recovery on mill feed running 20 to 25 pct graphite. It is designed to treat about 136 metric tons per day, and in 1944 it actually reached this rate. Today it treats about 100 metric tons. The graphite concentrate output capacity is about 1.0 to 1.3 metric tph. In 1944 the average was 30 metric tons of concentrate per day and the present output is about 25 metric tons per day. Labor employed for milling and other surface work normally totals about 180 men. The ratio of concentrate to ore was 1:5.0 in 1938 and was increased to about 1:4.1 by 1944.

Production Statistics

The earliest statistics available show a production of 798 metric tons in 1868 in the Passau area. Crude ore production rose from 5000 in 1908 to around 41,000 metric tons by 1918, and then dropped off to around 10,000 to 15,000 metric tons per year in the 1920's. In 1928 there were 11 mines with 14 shafts which together produced 17,500 metric tons of raw graphite worth about a half million Reichsmarks. By 1935 Kropfmuehl dominated the field, and their production in 1938 amounted to 28,100 metric tons of crude graphite from which about 7700 metric tons of graphite concentrate were produced containing 5730 metric tons of carbon. In 1942 production started to climb rapidly from the 1938 level, and in 1944 it amounted to 36,400 metric tons of crude and about 8900 metric tons of carbon in the concentrate. With the occupation, production stopped until March 1946. Kropfmuehl made large shipments and reduced its stocks prior to currency reform in June 1948 and then cut back its production temporarily

Fig. 3—Kropfmuehl mill.

because of a reduced inland market which has now recovered, see Table II.

Kropfmuehl requirements of selected mine supplies are given in Table III.

The electric power requirements of Kropfmuehl are at present about 300,000 kw-hr per month, and were as high as 450,000 kw-hr per month in 1944. The mine owns two hydroelectric plants with a combined capacity of 215,000 kw-hr per month when the water supply is sufficient. The balance is drawn from the Bavarian power grid. During power crises, such as that of the winter of 1946, the mine and the screening plant are kept operating but the concentrator is shut down part time. If the crude ore is stored too long awaiting concentration, the pyrrhotite and pyrite oxidize give bad flotation efficiencies and a high iron oxide content to the graphite.

There was no war damage at Kropfmuehl, only some pilferage of roofing.

Passau graphite has been well known in Europe since at least the beginning of the 15th century. Crucibles used by the alchemists were made of it, and Agricola mentions them for their refractoriness. The first crucible manufacturing was apparently at the village of Hafnerzell (now called Obernzell), and the clay bond was also mined in the vicinity. Crucibles of Passau graphite had a world market until about 1810 when Ceylon graphite displaced it, later itself to be displaced in many countries by Madagascar graphite. But again during World War I the Passau graphite had to cover almost all of the crucible needs of the Central Powers. After this war, the Weimar Republic government attempted to reduce imports and encouraged the continued use of Passau graphite for crucible purposes by requiring at least 50 pct Passau graphite in the graphite portion of the crucible formula. This requirement was lifted in 1922, however, partly because of quality. Under the Nazis there was an importation of about 1200 tons of Ceylon graphite and 900 tons of Madagascar graphite during the average year of the mid 1930s. Later with the completion of the modern flotation plant the quality was improved, and the prejudice of the German and other European crucible manufacturers against Passau graphite has now largely disappeared. In the period of the present occupation, crucibles are being made without imported graphite and the Kropfmuehl Co. claims that it can meet all quality requirements of its customers.

From the German viewpoint, there is no particular reason to emphasize the importance of flake sizes. The fine sizes also satisfy industrial needs for which imports would otherwise be necessary. In the export market, neighboring countries are interested in the fines as well as the flake, and they pay prices depending more on the carbon content than on the grain size. They are particularly interested in the uniform standard quality of deliveries.

The present grades and qualities produced by Graphitwerk Kropfmuehl are given in Table IV, which shows the carbon analysis, screen size, the internal German controlled price as it was prior to currency reform, and the monthly production and probable export availability of each grade. It will be noticed that the AF grade and three other grades of fines were valued equal to or higher than the flake graphite. It should be borne in mind, however, that price control on graphite has now been eliminated in the German market, and graphite for export is sold at competitive world prices.

Large industrial consumers use the Passau graphite for crucibles, pencil leads, lubricants, carbon brushes, search light carbons, electrodes for electric furnaces and for batteries, foundry facing, polish, pigment, etc., see Table V. About 25 pct of the

Table IV. Kropfmuehl Graphite Products

Grade Symbol	Carbon, Pct	Screen Size[a]	Maximum German Price, at Mine, Bagged, RM[b]	Kropfmuehl Monthly Production Estimate, Metric Tons		Description of the Graphite Product
				Total	Available for Export	
Flake Graphite:						
S 40	93/95	21/40	430	45	15	Large flake for crucibles
NFL	93/95	85/40	388	180	60	Normal German crucible flake
Graphite Fines:						
A F	96/98	1/140	640			Pencil grade, hammer-milled from flake
EDM	96/98	N.A.	493	55	25	Sometimes pencil grade, very fine
F P	96/98	24/100	430			Fine
EDM	90/92	3/140	400			Very fine
F P	90/92	N.A.	387	25	15	Fine
F P	85/87	33/100	304	100	40	Fine
F P	83/85	N.A.	278	75	30	Fine
F P	75/83	N.A.	225	20		Fine
		Total Production		500	185	

[a] Pct on a screen of given size: e.g. 33/100 means 33 pct on screen with 100 holes per sq cm.
[b] Prior to currency reform, June 1948.
For comparison:
40 holes per sq. cm. corresponds approximately to 18-mesh, U.S. Standard, or 1.0 mm particle size; 100 holes to 30-mesh, 0.6 mm particle size; and 140 holes to 35-mesh, 0.5 mm particle size.

Kropfmuehl graphite, however, is sold to dealers and its end use is therefore difficult to trace. Several large customers are located in what is now the Russian Zone of Germany. They include Lorenz Werk at Hainsberg and Graphit-Schmelztiegelwerk at Dresden for the manufacture of crucibles, and three companies manufacturing dry cells, two of which are in the Russian Sector of Berlin.

To summarize the viewpoint of the producers of Passau graphite with respect to their fines and powdered products, they would emphasize the uniform delivered size and quality of the various grades, also the low density, the very fine particle sizes of selected powdered products, the high refractoriness, and the good heat conductivity. They claim the density to be 20 pct lower than that of competitive materials which would result in a saving in certain applications, for example, of up to 25 pct in mixtures of the finest powders with oils for paints or lubricants.

The largest pre-war customers for flake graphite were the United States, Italy, England and Czechoslovakia; while the customers for Passau fines included almost every country in Europe, see Table VI. Contracts in the post-war period have been concluded with Czechoslovakia, Italy, England, Holland, and other countries at prices comparable to Madagascar graphite cif. European ports.

Graphite Crucible Manufacture

Crucibles were first manufactured in Germany in the Passau area. Probably because of insufficient clays of suitable properties in the Passau area and of difficulties with coal supply, the crucible manufacturing industry moved to the northwest and settled in Hesse and Thuringia. The Grossalmerode area, which is well known for its clay, is now the center of the industry in Western Germany. In this area there is also the manufacture of nongraphite crucibles, including glass pots.

It is the practice in Germany to specify that both the graphite and the clay must be free of impurities such as sulphur, iron oxide, and lime. The mix ranges upward from 30 pct graphite, and has 0 to 25 pct quartz with the clay, depending upon the intended application of the crucible. Some clay from Klingenberg, Bavaria, is added to the local Grossalmerode clay to increase its plasticity. The process used has been appraised by five British ceramists[7] who visited the area in 1945 with the purpose of observing any new methods. They concluded that the quality of product was to be attributed more to the care and craftsmanship of the workers than to modern practice or to any excellence in the plant equipment or its technical control. The constituents are mixed in Eirich mixers, then pugged and cut into lengths for maturing. The matured material is repugged and then fashioned into large balls by handwork. The crucibles are shaped from the balls by jolleying in plaster molds. After up to five weeks of drying in steam-heated drying rooms, the warm crucibles are painted with two or three coats of pottery-type glazes and fired in periodic kilns of a down-draft type at temperatures ranging from 1200°C to about 1350°C.

Since Madagascar flake graphite is at present the basis of the American graphite crucible industry, the properties and specifications for crucible graphite in America as reported by Gwinn[3] are analyzed here and compared with the properties and specifications of Passau crucible graphite. As delivered, it

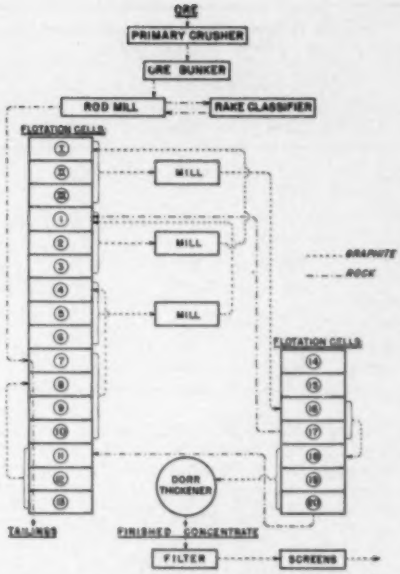

Fig. 4—Graphite concentrator.

is apparently higher in carbon content and lower in free impurities, especially mica, than the Madagascar graphite. These facts are evidently considered important in Germany, although Gwinn points out that American manufacturers seem to believe that there is nothing to be gained by using graphite containing more than 85 pct carbon since higher carbon content would mean reduced toughness of the flake.

As for size of crystals, the Madagascar flake can probably be delivered in commercial quantities in larger size flake than can the Passau graphite. Under the microscope the Passau S 40 grade appeared to average about 0.7 mm in diam and to range from 2.0 mm down to less than 0.5 mm. An available specimen of Madagascar graphite also examined showed about the same size range but a larger average diameter, and the crystals were thicker. It should be noted that Graphitwerk Kropfmuehl has stated that it could make a small tonnage of a coarser, S 20, grade on demand, which would probably average about 1 mm in diam.

Table V. West German Major Consumers of Passau Graphite

Firm	Town	District	Qualities
For crucibles:			
Becker and Piscantor	Grossalmerode	Hesse	S 40 and NFL
Aug. Gundlach	Grossalmerode	Hesse	S 40 and NFL
Carl Nolte	Frankenhain	Hesse	S 40 and NFL
Cosack and Co.	Neheim	Ruhr	NFL
For pencil leads:			
A. W. Faber-Castell	Nürnberg	Bavaria	AF
Eberhard Faber	Neumarkt	Bavaria	AF
J. S. Staedtler, Mars	Nürnberg	Bavaria	AF
Schwan-Bleistift	Nürnberg	Bavaria	AF
Joh. Froescheis, Lyra	Nürnberg	Bavaria	AF
For dry cells:			
Bavaria G.m.b.H.	Munich	Bavaria	FP 85/87 pct C.
Pertrix	Hannover	Lower Saxony	FP 85/87 pct C.
Koch and Krueger	Neukölln	Berlin	FP 85/87 pct C.
Schmidt and Co.	Charlottenburg	Berlin	FP 85/87 pct C.
Berliner Batterie	SW 61	Berlin	FP 85/87 pct C.

Table VI. Prewar Kropfmuehl Export Pattern, Metric tons per Year

	Flake			
	S 40	NFL	Fines	Total
Austria	3	10	130	143
Belgium			30	30
Czechoslovakia	30	80	320	430
Denmark			40	40
England		150	650	800
France			80	80
Holland			60	60
Hungary			100	100
Italy	120	290	310	720
Jugoslavia			40	40
Poland	35	30	50	115
Rumania			70	70
Spain			115	115
Sweden			120	120
Switzerland		15	85	100
United States	70	150	20	240
TOTAL	260	725	2220	3205

Compared to the Passau graphite, the Madagascar graphite showed relatively smooth surfaces and smooth edges that were either round or straight. On the principal cleavage surfaces of both there appear to be traces of three cross cleavages at approximately 60° angles, but in the Madagascar specimen they were more conspicuous and, in many crystals, parallel to the straight edges. It would appear that the Madagascar graphite specimen could have been better sized than the Passau graphite because of its smooth edges but actually it was not. Under the microscope it was noted incidentally that the Passau graphite has a higher lustre and reflection.

No specific information was available on Passau graphite with respect to the toughness or the packed-volume properties referred to by Gwinn.[6] However, it was claimed for the Passau graphite in the Tonindustrie-Zeitung[8] that despite its smaller flake size compared with Madagascar graphite, the Bavarian flake graphite is better for crucible manufacture because of its two superior properties, its superior refractoriness and its high heat conductivity. It is recognized, however, that American practice sometimes shows that a more refractory graphite does not necessarily give a better service life since crucibles, except those for aluminum, usually fail from abuse rather than from burning out.

Because of its flake shape, the Bavarian graphite enjoys the same advantage noted by Gwinn[6] as the Madagascar graphite over an acicular or granular graphite in that it can be oriented to form an interlocking structure with the flakes parallel to the wall surface of the crucible, thus providing the flexibility and strength necessary to resist the great thermal shocks to which crucibles are subjected. It is also claimed for the Passau crucible graphite that the crucible manufacturer does not have to clean it or mill it further.

Compared to American domestic flake graphite and again referring to the report by Gwinn,[6] it would appear that the Passau graphite would have had an advantage over the wartime domestic flake graphite in sizing and in toughness due to the probable superiority of the processing in the Kropfmuehl mill. It may be assumed that the flake toughness of the finished Bavarian graphite would have been greater because of its milling and given less breakdown in the mixing process of crucible manufacture. Better grading perhaps would have reduced the packed volume and therefore the necessary amount of clay binder.

It was learned by correspondence that the German crucible manufacturers do not anticipate any volume of crucible export to America at present, one reason being the 20 pct ad valorem import duty. The 30 pct ad valorem import duty on flake graphite itself should not, however, restrict direct import of German graphite any more than any other foreign graphite.

Acknowledgments

The material for this paper is drawn from observations made and information collected at the Kropfmuehl mine and concentrator and at their Munich offices during inspections in December 1946 and November 1948. In the latter inspection the writer was accompanied by D. E. Hartmann of the Geological Dept. of the Bavarian Bureau of Mines, whose work is drawn upon for the sketch map and structure sections, shown in Figs. 1 and 2. Pertinent Military Government reports also were used, and the standard published references consulted are listed in the bibliography.

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Rock Hardness as a Factor In Drilling Problems

by W. B. Mather

Literature dealing with rock drilling presents a mass of conflicting data. The principal cause of the confusion is attributed to varying definitions of the hardness factor of rock and cutting media. The future development of more efficient drilling methods demands that this problem be solved. The first step in the solution is the compilation of complete data on the physical properties of rocks.

A SURVEY of the technical literature concerned with oil well drilling methods and particularly with rate of penetration by various cutting media on different types of rock provides a mass of conflicting data. This is especially true with respect to, (1) the relative efficiency of diamond, rotary and percussion drilling operations; (2) the costs of the various types of drilling; and (3) the hardness factor of various types of rock and cutting media. The latter is the particular phase of the subject discussed here.

The cause of the confusion may be attributed partially to a lack of basic knowledge concerning the physical properties of the cutting media and of individual types of rock. It is also due in part to a general lack of uniform standards in the industry for evaluating the hardness versus drillability of rocks while possible errors in interpretation by the authors of the various papers pertaining to the subject may be an additional cause of misunderstanding.

The hardness of a mineral is defined by Dana[1] as "the resistance which a smooth surface offers to abrasion." Webster[2] states that hardness is "the cohesion of the particles on the surface of a body (as a mineral) as determined by its capacity to scratch another or be itself scratched."

Rock hardness, although not usually defined in publications describing rocks, is assumed to be the same as the minerals which compose the rock or the resistance of the rock to abrasion.

Drillability of a rock may be defined arbitrarily as the rate at which rock is penetrated by a definite type of drilling tool with the assistance of a specific type of cutting surface or medium and under specified conditions as to speed of rotation and applications of pressure.

Eventually the term penetrability may have to be employed to include any method of making boreholes in rocks, since methods other than those using conventional cutting surfaces are already in operation. A case in point is the jet piercing method[3] which employs an oxy-acetylene flame as a means of penetration.

The word hardness as used by the drilling fraternity has a variety of meanings which depend upon the type of drilling method employed. For example, in diamond drilling, hardness is interpretated as resistance to abrasion. In percussion drilling the term implies resistance to impact or indentation, while in rotary drilling, hardness is considered analagous to compressive strength. The three types of hardness—abrasion, impact and compression—are conflicting variables for different types of rock. Nevertheless, the term hardness is applied indiscriminately by the industry for the resistance of rock to penetration by any type of drilling technique.

Abrasion Hardness

Since 1818, Moh's scale of hardness, although only relative in nature, has been accepted universally as the method of measuring mineral and therefore rock hardness. In 1933, Ridgway, Ballard and

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Bailey[4] modified the upper, or harder, portion of Moh's scale, as shown in Table I.

If metallic media were included in the extension of Moh's scale, stellite would be placed at 8 and tungsten carbide at 12.

In 1935, Wooddell[5] measured the relative resistance of minerals to abrasion during lapping and proposed further refinements to Moh's scale in an effort to reduce the relative character of the scale and provide a numerical hardness value more in keeping with the comparative resistance to abrasion of the various minerals. This vastly improved measurement of abrasion hardness is shown in Table II with two sets of values depending on the choice of two mineral standards in Moh's scale.

In other words, the hardness ratio of South American brown bortz and quartz is 6:1 instead of 10:7 as one would infer from the old Moh's scale. The low tensile strength of diamonds permits their use only in diamond drilling where the load on the bit is relatively small and impact is reduced to a minimum. However, in the case of silicon carbide and fused alumina, which also have low tensile strengths, their lower hardness values does not permit their economical use in the facing of drill bits. After diamonds, boron carbide is the hardest mineral substance, and although it is very resistant to abrasion, its low tensile strength prevents its use as a cutting medium.[6]

Tungsten carbide, because of its greater tensile strength and a hardness value of nearly twice that of quartz, has been found to be the most satisfactory material for the facing of rotary and percussion bits where load and impact factors are of major importance.

In diamond drilling operations in Crane County, Texas, McCray[7] reports, "As different strata of limestone drill at widely different rates, varying from perhaps 6 or 8 to 90 minutes per foot, and as sandstones generally core at rates from 5 to 10 minutes per foot, much faster on the average than limestones or dolomites, it must be concluded that hardness is not a factor of the rate of penetration." He also observed that "very finely crystalline limestones were the slowest drilling of all rock sections penetrated. Limestones and dolomites formed of larger crystals drilled faster—sandstones which drill faster than limestones, in general have grains whose sizes are considerably greater than limestone crystals. On the other hand, the mineral of finest crystalline structure, the chert, is drilled at rates from 20 to 30 minutes per foot or 3 to 5 times faster than the finely crystalline limestone. This fact is largely explained by the tendency of chert to chip out with a characteristic conchoidal fracture."

According to Christensen's charts[7] of diamond drilling time on the various members of the Weber sand section at Rangely Field, Colo., dolomite was penetrated at an average of 8.5 min per ft, sandstone at 8.7 min per ft and shale at 13.4 min per ft.

From experience in diamond drilling pre-Cambrian marbles, dolomites, and quartzites, the author observed that the marbles and dolomites were penetrated much more rapidly than quartzites. These observations indicate that the resistance to abrasion of the respective mineral components of the rock was definitely a factor in rate of penetration. On the other hand, the greater difficulty often experienced in diamond drilling shale is incongruous, since theoretically it is composed of much softer minerals than those in limestones, dolomites, and sandstones.

In Southwest Research Institute drilling experiments using tungsten carbide, alundum and carborundum as cutting media, it was observed that fine-grained Austin chalk was penetrated much more rapidly than coarser grained Edwards limestone. This fact is explained partially by the greater degree of cementation in Edwards limestone than in the Austin chalk in spite of the fact that chemical or mineralogical analyses would show that both rocks had nearly identical compositions.

Table I. Modification of the Upper Portion of Moh's Scale

Moh's Scale		Extension	
(6)	Orthoclase	(6)	Orthoclase or Periclase
		(7)	Vitreous Pure Silica
(7)	Quartz	(8)	Quartz
		(9)	Garnet
(8)	Topaz	(10)	Topaz
		(11)	Fused Zirconia
(9)	Sapphire	(12)	Fused Alumina
		(13)	Silicon Carbide
(10)	Diamond	(14)	Boron Carbide
		(15)	Diamond

Table II. Measurement of Abrasion Hardness

	Scale	
	Corundum = 9 Diamond = 10	Quartz = 7 Corundum = 9
Rock crystal quartz	6.94	7.0
African crystal corundum	9.00	9.0
Fused alumina	9.03	10.0
Fused alumina (3.14 pct TiO_2)	9.06	11.0
Tungsten carbide (13 pct cobalt)	9.09	12.0
Green silicon carbide	9.13	13.4
Black silicon carbide	9.15	14.0
Boron carbide	9.32	19.7
South American carbonados	9.82	36.4
Belge Congo gray opaque (cubic xals)	9.89	38.7
Belge Congo clear white (cubic xals)	9.95	40.7
Belge Congo yellow (cubic xals)	9.96	41.0
South American ballas	9.99	42.0
South American brown bortz	10.00	42.4

Impact Hardness

Resistance to impact or indentation is the principal type of hardness envolved in percussion drilling. Klapka[8] presented the data shown in Table III based on the indentation tests of Knoop, Peters, and Emerson of the National Bureau of Standards and Wooddell's abrasion tests previously mentioned, as compared to Moh's scale of hardness.

The variance in the comparative hardness of the cutting media by the two methods of measurement are obvious, where the ratio of diamond to tungsten carbide and to quartz by the abrasion test is 3.5:1 and 6:1. By the indentation method, it is more than 7:1 and more than 10:1. More conspicuous, however, is the reversal of position of tungsten carbide and corundum in the two tests with tungsten carbide, the harder material by abrasion tests, and corundum, the harder by the indentation method.

Irrespective of these laboratory tests, in actual drilling practice tungsten carbide is used in facing percussion tools because of its toughness and ability to withstand impact. The materials shown to be most resistant to impact by the indentation tests, such as diamonds, silicon carbides, and corundum, cannot be used because of their ease of fracture under impact. It therefore appears that in measur-

Table III. Moh's Scale Compared with Indentation and Abrasion Tests

Indentation Tests	Moh's	Abrasion Tests	Moh's
Diamond 8200-8500	10	Diamond 42	10
		Black silicon carbides 14	
		Tungsten carbide 12	
Silicon carbides 2050-2140			
Corundum (sapphire) 1700-2200	9		
		Corundum 9	9
		Quartz 7	7
Tungsten carbide 1050-1500			
Topaz 1250	8		
Crystalline quartz 710-790	7		
Gypsum 32	2		
Talc	1		

ing impact hardness the elasticity and tensile strength of the material are the important factors which should be determined.

Compression Hardness

Table IV by Norton Co.[10] of resistance to compression (compressive hardness) indicates that this type of hardness as applied to cutting media compares favorably with abrasion hardness and to a lesser extent with impact hardness.

The ratio of hardness of silicon carbide to quartz by the three methods is: abrasion hardness, 2:1; impact hardness, 2.7:1; compression hardness, 1.4:1.

Scott[11] in discussing hard-rock rotary drilling, defines hardness of a rock as "its comparative crushing strength or resistance to penetration." He further defines drillability "as a rate-weight ratio where rate is feet per hour and weight is pounds force acting on the bit." These definitions, which apply only to penetration of rock by rotary drilling tools, are in agreement with other authorities who believe that hardness in rotary drilling is resistance to compression or crushing and therefore the compressive strength of a rock would be a measure of its hardness.

The relation between compression and impact hardness as demonstrated by Bond[12] are given in Table V.

This table clearly exemplifies the discrepancies existing between compression and impact hardness. For example, according to the compression tests, shale is the softest rock, while Virginia granite is softer than six limestone specimens but harder than the remaining three limestones. On the other hand, according to impact hardness, shale is harder than granite and in addition is harder than seven out of nine limestone specimens. If abrasion tests had also been performed on these specimens, the results would have followed more closely the results of the compression rather than impact tests except that the two granites, which by definition are composed mostly of quartz and feldspar, would have proven harder than all limestone specimens, with the shale the softest of the materials tested.

Summary

Only the most obvious inconsistencies in our present usage of the term "hardness" have been presented.

In the case of diamond drilling or in similar methods of rock penetration where abrasion is believed to be the governing factor, there are other variables which cloud the picture. For example, there is the contention that finer grained rocks are more difficult to penetrate than coarser grained rocks of identical mineral composition, where the only apparent difference in these two rocks is that the finer grained type contains more grain boundaries than the other, the inference being that grain boundaries exhibit a greater resistance to abrasion than the interior of the grain. In addition to rock texture, the degree of cementation, variation in mineral content, and existence of incipient fractures also have a marked effect on abrasion hardness. The longer drilling times required to cut shale[13] than dolomite and other rocks of greater abrasive hardness may be attributed to the lubricating action of the soft shale particles on the drill face. The very fact that in certain cases chert, a rock of highest abrasive hardness, cuts more rapidly with a diamond drill than fine-grained limestone[14] indicates that other physical properties of rock are of major importance. The effect on abrasion hardness of other physical properties, such as elasticity, thermal expansion, grain and crystal orientation, compressive and tensile strength, etc., have not been definitely determined. However, Norton[10] states that hardness or resistance to abrasion is a function of interatomic distance, where the hardness decreases with increase in distance between the atoms if the charge of the ions is constant. Since the interatomic distance is dependent on the ionic charge, both factors are at least partially responsible for this type of hardness. He further points out that compounds with layer structures are usually softer than those without the layer structures and that hardness may vary with crystallographic direction because of crystal structure. This latter factor he believes to be of less importance than interatomic distance and ionic charge.

The present value of impact or indentation hardness and tests as a measuring device for ease of penetration by percussion tools is highly questionable. It appears that elasticity, tensile and compressive strength are at least in part the governing factors in resistance to impact. The observation that percussion tools are often more successful in drilling shales than rotary and diamond drills does not depend upon the impact hardness of the shale, which is very high while its compression and abrasion hardness are low, but rather that the lubricating action of shale particles has little if any effect under impact while they are effective on rotating bits.

Table IV. Resistance to Compressive Hardness

Material	Ultimate Strength in Compression (psi)
Molded boron carbide	300,000
Dense silicon carbide	82,000
Crystalline alumina	75,000
Optical quartz	58,000
Fused silica	38,000

Table V. Relation Between Compression and Impact Hardness

Material	State	Compression, Psi Max.	Compression, Psi Min.	Impact, Ft-lb Max.	Impact, Ft-lb Avg.
Limestone (fine)	Mich.	15,480	14,220	12.0	6.09
Limestone (white)	Mo.	10,830	10,285	7.8	6.26
Limestone	Mo.	16,120	10,100	12.1	7.18
Granite	Va.	17,200	15,030	13.4	11.20
Granite	Ga.	27,600	17,223	14.9	11.42
Limestone	Wash.	22,000	16,683	17.5	12.20
Limestone	Wyo.	30,000	27,730	20.5	12.60
Limestone (gray)	Mo.	15,960	14,410	19.7	13.16
Limestone (coarse)	Mich.	19,160	16,785	27.0	14.75
Shale	Pa.	9,100	8,160	22.1	15.06
Limestone	Ark.	24,480	20,050	23.2	17.91
Limestone	Mo.	23,540	19,222	23.8	18.00

As previously indicated, compressive strength may be an important factor in diamond and percussion drilling. Rotary drilling of granite is recognized by the industry as being more difficult than the drilling of limestone, yet according to compressive strength tests, Virginia granite should be easier to penetrate than six of the nine limestones tested by Bond,[16] while Georgia granite should be less difficult to drill than three of them. Therefore, the suggestion that compressive strength is the governing factor in rotary drilling is open to question since other factors such as elasticity, abrasion hardness, and tensile strength are believed to be equally contributing factors.

The tensile strength and elasticity of minerals and rocks as well as cutting media are believed to be two of the most important factors in drilling of any type, yet they are almost totally ignored in studies of drilling problems.

Other physical properties of rocks, at present considered unimportant, may be the bases of developing new drilling techniques and equipment in the future; as an example, in the jet piercing method of drilling, where thermal expansion is the important physical property.[17]

The disparity between laboratory data and actual drilling results may be attributed partially to variations in the physical properties of minerals and rocks when buried under several thousand feet of rock. If this is the case, the question then arises as to the character of the changes and the rate of variations likely to be encountered at various depths below the earth's surface.

Conclusion

The need for more complete data on the physical properties of rocks is apparent. A considerable portion of the information that may be found in the literature should be compiled and a research program instituted to furnish the missing portions in the data.

Since this study was undertaken on behalf of petroleum industry, the data were to a large extent secured from that source. In spite of the fact that in the past the diamond drill has been primarily the tool of the mining industry, apparently the oil well driller has to a large extent ignored the experiences of the miner in the use of this tool. The petroleum industry has attempted to equip the rotary rig with diamond tools for which they were never designed. The oil well driller has learned the hard way that the slow rotary speeds and high bit pressures necessary for rotary drilling will not produce satisfactory results with a diamond bit. Similarly if the mining industry anticipates the use of rotary and cable-tool drills, it would be wise to study the experiences of the petroleum industry.

The basic problem of determining the physical properties of rocks is applicable to both industries and the knowledge gained will be of equal benefit to both. Therefore I believe that the work of Obert, Windes and Duvall at the U. S. Bureau of Mines[18-23] on the determination of the physical properties of mine rock could be employed as a starting point for future investigations. Their excellent work included tests of sonic properties, compressive strength, modulus of rupture, scleroscope and abrasive hardness, and impact toughness on various types of mine rock. Their suggestion that detailed petrographic studies should accompany the physical tests is sound. They also found that there are few studies in the literature pertaining to the hardness of rock.

Since complete information on the physical properties of rock should be of greatest potential value to the petroleum and mining industries, it would appear that they are the logical sponsors of such a research program.

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A Pattern for Sound Fuel Procurement

by Marshall Pease, Jr. and Raymond J. Brandon

A pattern for providing a large utility, The Detroit Edison Co., with an adequate fuel supply is outlined. From the standpoint of both fuel procurement and utilization, consideration has been given competition relationships, fuel properties as well as operating conditions that must be met to provide dependable service and reliable plant operation.

A UTILITY that has a large consumption of coal must insure an adequate and sound supply of fuel. The Detroit Edison Co., which has an annual coal consumption of about four million tons and spends approximately $32 million a year for coal, including freight charges, has developed a program for fuel procurement and for evaluation and selection of fuel for reliable and efficient plant operation.

Fuel Procurement

Coal Purchasing Division: The Fuel Supply Div. of the Purchasing Dept. combines all of the procurement functions in one group, which must maintain adequate stocks of fuel. In addition to its usual purchasing duties, the division also governs transportation, follow-up, invoice and freight bill, in cooperation with the Accounting Dept. The Fuel Div. is comprised of the fuel agent, an assistant fuel agent, a coal buyer and five coal clerks, who follow the movement of each car, initially approve freight bills and invoices, and file claims whenever there is a shortage of one ton or more. The fuel agent reports directly to the purchasing agent of the Company, and all major programs are planned jointly with the chief purchasing officer.

The apparent individuality of the fuel section is necessary because of the tremendous volume of coal cars handled each day, sometimes as many as 500, which must be handled promptly to complete the fastest possible move from the mines to the plants.

Determining Annual Coal Volume: Through the combined studies of a Production Dept. Load Committee and the Controller's office, accurate predictions of coal requirements for any given year are provided the Fuel Dept. from 12 to 15 months in advance. This is divided into the requirements of all individual power plants and central heating plants. This in turn determines the quantity and quality for plants whose specific fuels vary with the type of equipment installed. In the Detroit area, which has a high industrial load, early estimates of annual coal consumption usually are resolved at the end of the year within 4 or 5 pct of the original plan.

Operating in a highly developed industrial area eases the task of estimating primary output; and, with the residential demands increasing in a steady and fairly well-defined pattern, the overall coal schedules are not subject to radical changes during any given year.

Selecting Suppliers: At any time, but especially during or before an emergency, the coal supply factor must be made secure. This is particularly true in the procurement of utility fuel. There are always extreme quantities of so-called "bargain" coal available during the buyers' markets, such as recently prevailed. These opportunistic offerings may be considered a means of averaging down overall price, rather than as a steady and dependable supply source.

Coal is purchased on contract from mine operators and sales agents who have proved reliable. They are not opportunists who desert for higher dollars in times of duress; they do not fail to fulfill contracts when markets rise or overship when markets dip.

The progressive operator today who is willing to expend capital to improve quality and service deserves much more consideration than a matching of short-term pennies.

When a company has a high volume of annual needs, all phases of the mine supply must be considered. The mine must be able to produce the quality required at a fair price and be able to sell oversizes of coal in enough volume to screen sufficient nut and slack. It must crush coal and sell mine run at prices in line with competitive nut and slack and be willing to do so when there is no demand for prepared sizes.

Determining Price: The public utility is in direct competition with any of its customers who can, if savings are guaranteed, generate their own power. Today, to a greater extent than ever before, private industry must do a better overall job than Government-controlled operations. The price of coal must be realistically balanced with the price paid by almost all industries and the railroads as well.

The supply-demand ratio in coal is not difficult to discern. There is access at all times to Govern-

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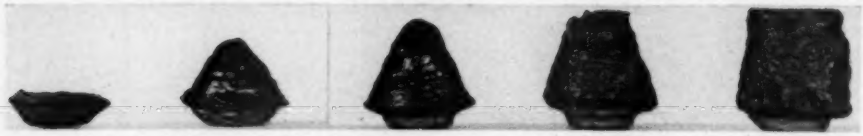


Fig. 1—Coke buttons obtained by British standard method for the crucible swelling test for coal.

ment Bureau indices, to car-loading records, to weekly production figures, and to consumption of coals by all users. Continuing studies of these phases will give the overall outlook in a broad sense. Actual market prices by reviewing government, state and municipal bids must be checked and the market followed daily through personal contacts.

When coal production is greater than the demand, there is ordinarily a price spread in favor of open market purchase over contract purchase. Here, the utility buyer must try to forecast the longer term prospects and adjust his ideas of the necessary contract tonnage protection to the overall economics. The Detroit Edison Co. uses mutually acceptable cancellation clauses on its coal contracts, which give both parties the right to arbitrate the price when lower market prices justify. A sensible balance must be maintained between price, quality, and dependability of supply at all times.

Proper Storages: All of the company's plants are located so that a water-borne self-unloading boat delivery from Lake Erie loading ports has proved to be the most economical and practicable method of delivery. Hence, nearly all annual coal requirement is floated during the eight to nine months of navigation. In this respect, sufficient coal is delivered by boat to insure full consumption for the entire system between March 15 and Dec. 1, plus enough storage coal to provide about 150 days' supply at Dec. 1.

If coal is bull-dozed into all power plant storage sites, there is no danger of spontaneous combustion. Weather conditions, therefore, do not delay stocking programs, and coal is put on the ground during each and all of the months of navigation.

The Fuel Div. works closely with the Production Dept. in advance of each month's coal delivery to plants. Schedules are arranged to provide the most flexible means of boat delivery as well as reduce to a minimum any cause for overtime in the stocking of coal.

Market Studies: To properly define a coal market, the geological factors of coal origin and development must be known. This is accomplished through general tests and Bureau of Mines data. The coal buyer must know the characteristics of coal by seams, whether friable or firm, and of byproduct or steam quality.

Information on competing producing districts and the usual markets supplied may be obtained from the Dept. of Interior, Bureau of Mines Industry Surveys, and also coal trade association reports and studies.

The freight rate patterns on all coals that might be available for use must be at the buyer's disposal at all times. This requires a familiarity with railway tariffs and a close association with railroad coal department representatives. The fuel buying policies of railroads using coals similar to those of the purchaser can often assist in determining reasonable prices.

When competitive buying is a factor, the coal buying policies of other large consumers can be determined by monthly Dept. of Interior reports of consumption and storage, plus acquaintance, and the National Assn. of Purchasing Agents' monthly bulletins.

The conditions that control the market are national production, consumption, storage programs, seasonal fluctuations, the retail situation, and export needs. This knowledge is acquired by experience and continuous contacts with people involved in the entire coal industry.

Knowledge of the operating end of the mining business is important in fuel procurement. The buyer must know the type of mining, costs, cleaning facilities, capacity, life of mine and future development, financial condition and the mine management personnel. Thorough inspection visits are required periodically to key mines.

Contract negotiations between the mines and the miners' union must be followed closely. The major upsets to coal production brought about by strikes during the past ten years clearly indicate the importance of providing sound storage protection for coal-burning utilities.

The coal buyer will benefit by a careful review of his coal specifications. If they are restricted, he must find out why. Plant modernization or expansion must be preceded by and based upon a comprehensive study of all the low-cost coals available.

Selecting and Evaluating Fuels

It would be impractical to attempt to set up a rigid pattern for utility fuel procurement that would be economically valid or sound for the varied fuel procurement conditions encountered in the utility industry. Some principles that may have some general application in regards to fuel procurement as related to power plant operation and equipment may be established by a description of this phase of the fuel procurement pattern of The Detroit Edison Co.

The primary concern of the utility is to have its product available at all times for the service of its users, and the procuring of fuel for reliable service and efficient plant operation is an important part of this overall aim. Since coal constitutes from 97 to 98 pct of the total fuel burned in the Company's plants, it is logical that discussion should center first around the procedure for selection and evaluation of this fuel.

Coal selection is a matter of appraising a variety of combinations of chemical and physical properties of coal as they affect the performance of the plant

in which the coal is to be burned. As an indication of the complexity of the problem, the properties of the coals may vary among individual mines, among producing areas and among seams. One or more of these properties may affect to some extent either the load-carrying capacity or operating expense of the plant. The limiting of steam generating capacity because of one or more of these characteristics is the most serious. If the plant cannot generate sufficient steam to carry the plant load because of some coal property, the coal having that property cannot be used at any price. The possibility of variation in coal properties, together with the changing competitive picture of fuels, makes it necessary to keep reviewing the fuel situation so that selection and evaluation will result in the most economical fuel from both a purchasing and operating standpoint.

Selecting Coal from One Field

In the selection and evaluation of coals from mines in one field or district, which is the most commonly made, the first step is the analysis of coal samples. To obtain these samples, two or more cars of coal are shipped direct from the mines to one of the company plants where representative samples are collected. As a means of checking the quality of the product from regular shippers, a testing schedule is set up whereby these coals are analyzed periodically. The number of times a mine is sampled during the year depends on the tonnage shipped and its variation in quality during past years. In considering the purchase and burning of coal from an unfamiliar mine in this field, the same procedure is followed, and after the samples are collected they are sent to the laboratory where they are analyzed for various chemical and physical properties. These properties are discussed from the standpoint of coal selection and their effect on plant capacity, efficiency, and operating expense.

Ash Fusion Temperatures: From an operating standpoint, the coal property that is of primary importance is the ash fusion temperatures. Since a large portion of our fuel-burning equipment is designed to burn coals with ash-softening temperatures of 2500°F or higher, coals with low ash-fusion temperatures can cause clinkering on the stokers and collection of ash deposits difficult to remove from the heat transfer surfaces of both stoker-fired and pulverized-fired furnaces. Besides causing continual operating difficulties and increased operating expense, these coals usually cause a decrease in boiler availability and capacity, resulting in reduction of plant load. For equipment designed to handle high fusion coals, selection should be limited to coals with this characteristic. Increased operating and maintenance expense may more than offset any delivered price advantage. The *ash-softening* temperature is a fairly reliable guide to the clinkering that can be expected for a coal fired on stokers, but the *ash-fusion* temperatures also must be considered in pulverized coal firing. The laboratory test for the ash-fusion temperatures is conducted in a reducing atmosphere that is similar to conditions surrounding the ash in stoker firing, but the fusion temperatures may be raised from 100° to 500°F if the atmosphere is oxidizing in the pulverized coal-fired furnace. In pulverized coal firing, the coal and ash particles are finely divided and if some of the ash constituents with a low melting point become separated from the ash, severe slagging may occur. In observing burning tests on coals on the borderline for this coal property, many coals performed satisfactorily until boiler ratings were increased or until furnace atmosphere conditions temporarily changed, allowing slag to start to collect on the tubes and becoming progressively worse until it became necessary to shut down the unit for cleaning.

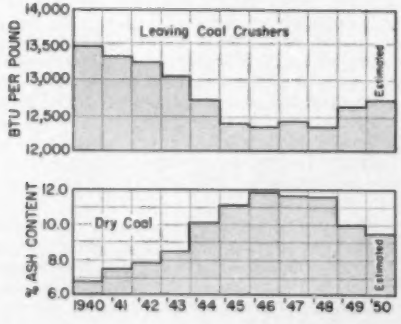


Fig. 2—Average heating value and ash content of coal burned in power plants.

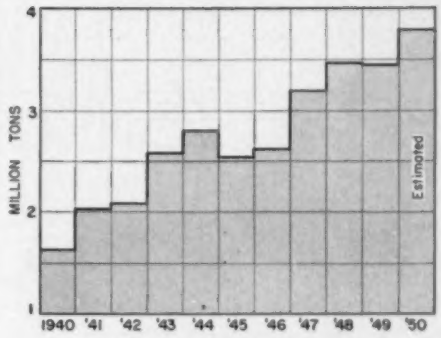


Fig. 3—Annual power plant coal consumption.

Moisture Content: Besides displacing useful heating value of the coal, high surface moisture values can cause difficulty in unloading coal from cars, plugging of coal-handling chutes and stoker hoppers and reduction in pulverizer mill capacity. Steam generator efficiency is decreased since the moisture in the coal must be evaporated and superheated.

Loss of feed to the pulverizer mills, which is caused by wet coal hanging up in the chutes and feeders, and loss of mill capacity due to high moisture values are probably the most serious of the operating difficulties where the direct firing system is installed. While the inherent moisture in the coal is not detrimental to coal preparation like other forms of moisture, it delays ignition and makes the fires unstable, particularly at low rates of firing. The moisture in coal first must be evaporated before the temperature of the coal can be raised to the ignition point, and the time required to evaporate the moisture causes the delay in ignition. If a coal with high moisture content is to be purchased and burned, consideration should be given to the means of supplying hotter air to the mill so that more of the moisture will be evaporated before the coal reaches the burner. Although the

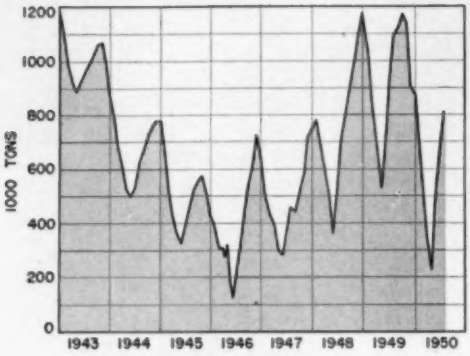


Fig. 4—Total power plant coal stock.

air temperature may be high enough at full load ratings, at low ratings it may not be enough to prevent the instability of firing that often occurs because of moisture. Coal feed to sections of the stoker may be stopped, resulting in parts of the grate area becoming bare with resultant increased maintenance expense due to replacing burned and warped iron.

Sulphur: The final flue gas temperature leaving the economizer or air heater depends on the sulphur content of the coal fired, and there is a lower limit of flue gas temperature that can be attained. Below this limit the dew point is reached, resulting in costly corrosion. In short, the sulphur in the coal will either cost money for replacing equipment or some efficiency of the boiler unit must be sacrificed. The latter is usually chosen as less expensive.

Ash Content: The quantity of ash in the coal decreases proportionately the amount of energy-producing material in each ton of coal. Any increase in ash content requires the handling, removal, and disposal of large quantities of the material, resulting in increased operating and maintenance expense. The efficiency of the boiler unit is usually reduced when burning coals of high ash content because of the increased amount of combustible entrained with the ash and carried into the refuse. When high ash coal is burned in the pulverized form, the ash is always detrimental because more of it must be removed from the furnace and boiler settings, and unless ash collection is designed for the higher ash content, increased stack discharge is a nuisance for the people living in the surrounding area. Some ash is necessary to protect the grates in underfeed stoker firing, but when burning high ash coal, a larger percentage of the fuel bed consists of ash that tends to retard combustion. The quantity of ash as well as its composition has a decided effect on plant operating expense because of the increased maintenance required on the ash handling, coal handling, preparation and burning equipment.

Swelling Index: In the large stoker-fired plant, the coking property of the coal has a decided effect on operating control of fuel bed conditions. Many tests have been formulated for determining this coal characteristic but the subject is complex due to the widely varying composition of the coals which has a marked effect on coal coking quality. The amount of swelling of the coal when heated has been correlated with the coking properties so that it indicates somewhat the coking quality of the coal. The range of values of this index varies from one to nine in half numbers with coking properties increasing with the index number. Fig. 1 shows some of the coke buttons obtained by this test, which covered a range of values, and shows how the swelling varies for different coals. This index is most important to The Detroit Edison Co. in mixing coals with about the same swelling number for shipment and burning at the stoker-fired plants. Where it is necessary to burn a mixture of coals from many mines and seams, better control of the fuel bed and more stable fires can be obtained, usually resulting in higher efficiency if coals with about the same coking characteristics are mixed for burning. Since it usually is not possible to mix coals thoroughly, air distribution through the fuel bed is more difficult to control when coals with different coking characteristics are burned on the stoker at the same time. Because of unequal combustion air distribution, coal burning rates on some parts of the stoker are exceedingly high with resultant high temperatures causing burned iron and high stoker maintenance. The uncoked particles of the free burning coal may be blown either into the ash pit with high carbon loss or carried into the gas stream where the ash may collect on the tubes because the burning carbon keeps the ash plastic and provides a reducing atmosphere with lower ash-fushion temperatures. In selecting and mixing coals for the plants, the coals with the highest index numbers are delivered to the plants with the highest coal burning rates, since a high quality coal with good coking characteristics is needed for high stoker ratings.

Volatile Matter: Depending on the completeness of its combustion, the volatile matter of the coal may or may not result in some decrease in steam generation efficiency. About 30 pct of the heat in the coal is contained in the volatile matter because of the high heating value of the constituents; a small amount that might escape without being burned can affect the efficiency considerably. In the selection of coals, the bituminous coals may be classified broadly as high and low volatile coals, and it is not usually practical in most furnace designs to burn these coals interchangeably because furnace design changes and changes in operating control are required. Since a greater amount of gas is given off in the pulverized fired furnace, the high volatile coals ignite and burn more rapidly than the low volatile coals and produce a richer gas and air mixture in a shorter time. In order to approach this condition with low volatile coals, it is necessary to reduce the primary air so that a richer mixture can be obtained at the burner. It may be necessary, however, to reduce the air flow to a point where the air will not pick up the coal in the mill, and the quantity and temperature may be insufficient for providing adequate evaporation of moisture in the mill to prevent delayed ignition and unstable fires. By increasing the secondary air pressure, greater turbulence is created, resulting in more rapid ignition. Besides these changes in control, it may also be necessary to provide some reradiating refractory surface in the burner zone to bring the coal up to ignition temperatures more rapidly.

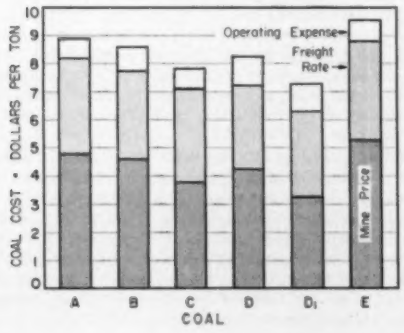
Grindability: The grindability index is of decided value not only in selecting coals for existing plant mill capacity, but also in installing new mill capacity where consideration should be given to the range of grindability of the coals that may be purchased

and burned. Coals with low grindability may reduce mill capacity to the point where the coal prepared and fed to the furnace is not sufficient to generate the required amount of steam for plant load requirements. Grindability is reported as an index number, and the higher the index number, the easier it is to grind the coal. Although mill characteristics vary considerably, for some coal mills, where all other components such as moisture content, size of feed, and fineness of product are the same, the capacity of the mill increases almost directly with the grindability of the coal, so that when grinding coal with a grindability index number of 100, the mill capacity is about double that obtained when using 50 grindability coal. The energy input to the mill is the same regardless of grindability, so that when mill capacity is increased, the energy per ton is decreased accordingly. Usually the low volatile bituminous coals are of softer structure and easier to grind, and a finer product is obtained from the mill. With a decrease in volatile matter, the coal must be ground finer if rapid and complete combustion is to be obtained. Unless the coal fineness is increased, the carbon loss in the refuse increases with a resultant efficiency loss. When changing to a harder coal, the size of product from the mill should be checked to determine if coarse particles are being fed to the furnace. The larger particle size not only increases carbon loss but also tends to aggravate slag collection on the tubes because of the sustained heating of the ash associated with the combustible matter and because of the reducing action of its combustible matter on the ash constituents.

Of course, the actual suitability of any coal for use by The Detroit Edison Co. depends on its performance when burned in the plant equipment. In any case where the analysis indicates that there might be a question of the coal's causing operating difficulties a burning test is conducted and the coal judged on the merits of its actual performance.

The trend of some of these coal characteristics during the past ten years is shown in Fig. 2. The average ash content increased from a 1940 average value of about 7.0 pct to a maximum of 12.0 pct, and the average heating value decreased from about 13,500 Btu to 12,300 Btu. If the reduced heating value, together with increased coal costs and freight

Fig. 5—Comparative cost of coal, competitive coal fields.



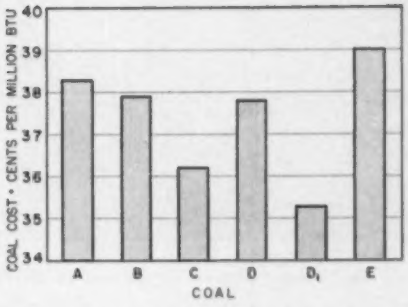


Fig. 6—Comparative cost of coal, competitive coal fields. Based on heat absorbed in steam generating unit.

rates, is considered, coal costs have more than doubled during this period. During the major portion of this period, it became a question of obtaining coal for company needs rather than selecting coal on the basis of quality or suitability for the burning equipment. With coals unsuitable for the equipment and high boiler ratings, many operating difficulties were experienced together with increased plant operating and maintenance expense. Fig. 2 indicates a gradual improvement in coal quality during the past two years. It is questionable whether these values will return to previous low levels. With the increase in coal tonnage mechanically mined and cleaned by washers, some increase in moisture content can be expected, and there is an economic limit to the amount of impurities that can be removed without an excessive loss of valuable coal.

As in practically all of the electric utility industry, a rapid increase in load growth and output has been experienced by The Detroit Edison Co. during the past 10-year period with a resultant increase in coal consumption. The trend for this period is shown in Fig. 3 and indicates an increase in power plant coal consumption of about 132 pct based on consumption in 1940. Since all indications point to a continuation of this growth, the coal industry will be called upon to meet ever-increasing coal requirements.

In conjunction with increased coal consumption is the need for increased handling and storage facilities. As mentioned previously, the aim of the utility is service, and a protective coal storage supply must be provided so that continuity of service can be maintained during emergency periods. The tonnage of coal in storage at this company's power plants for the past seven years is shown in Fig. 4, which reveals the emergency condition encountered and the unsettled pattern for fuel procurement and company protective coal storage. Anticipating a greatly increased demand for coal occasioned by the war, protective coal stocks were built to abnormally high levels during the early war years and burned later when coal was in short supply. Twice during this period it was necessary to install oil-burning equipment and burn oil in rather large quantities to conserve coal stocks. From an economic viewpoint, the burning of oil could not be justified since the equiva-

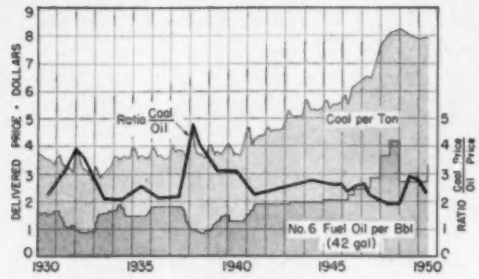


Fig. 7—Comparative prices, coal and No. 6 fuel oil.

lent oil price was about twice the coal price and resulted in higher operating fuel costs.

Evaluation of Coal from Competitive Fields

The evaluation of coals from competitive fields must be considered when building new or rebuilding old plant equipment. Trends of supply and price must be studied in an attempt to foresee what coals may be economically purchased and burned in this equipment. An evaluation of the coals must be made in order to eliminate coals that from a competitive standpoint probably will never be purchased for the new or rebuilt plant equipment and would not justify added plant investment to handle them. As shown in Fig. 5, comparative coal costs for some of the competitive coals have been plotted. To obtain the heat absorbed in the steam generating equipment when burning different coals, it is necessary to consider the coal heating values and steam generation efficiencies. With this information the cost per million Btu absorbed in the steam generator may be calculated, see Fig. 6. Although many comparisons are made on the basis of delivered coal prices alone, the competitive relationship can be changed completely, depending on the coal heating values, steam generating efficiencies and plant operating expense. The names of the coal fields have been purposely omitted since the coal analysis is representative of only certain districts of these fields. The evaluation is based on the burning of these coals in a pulverized fuel fired furnace of liberal design. It would not necessarily hold for other types of firing or when attempting to burn coals of widely varying properties in equipment already installed. The properties of these coals from the various fields vary widely, with the ash-softening temperature ranging from 2100°F to 2600°F. A design to cover this range would not be justified unless the coals are competitive, and the savings that may be effected can justify the additional investment. From an operating standpoint, furnace design should be liberal in respect to heat transfer rates so that continual operating troubles, decreased availability and increased operating expense will not be encountered during the life of the equipment.

Besides making an economic study and evaluation of coals that might be competitive, it is also necessary to consider the dependability of supply and the quality of product that may be expected in the future. Change in coal quality may increase plant operating and maintenance expense materially besides decreasing the availability of the equipment. Of course, any change in the relationship of mine prices, freight rates or quality of coal between the coal fields may change the picture completely. As a basis for forecasting the trends of mine prices, the published mine production costs for the various districts is useful. Although freight rates have increased considerably in the past few years, the relationship of transportation costs between the various fields has been established over a long period, and it is doubtful that any radical change will occur in the near future.

Evaluation of Competitive Fuels

Although the delivered price of coal from various fields usually bears some relationship, the price of competitive fuels such as heavy fuel oils or natural gas may fluctuate widely and not change necessarily in relation to coal prices. The geographic location of the utility in relation to fuel source and refining areas, together with relatively cheap water-borne transportation freight rates, determines to a great extent the possibility of heavy fuel oil being competitive with coal. Where the fuel cost is only a small part of the total production cost of the product and the characteristics of this fuel are desirable in the manufacturing process, industry is willing to pay a premium to obtain this fuel. When industrial demand was strong, prices remained firm and only competed with coal during periods of business inactivity when heavy oil came on the market at distress oil prices. In Fig. 7 the price of heavy fuel oil and coal has been plotted for a 20-year period. Examination of the price ratio indicates that there were only two periods when heavy oil was competitive with coal for The Detroit Edison Co. use as fuel. These are published prices and some oil was sold at lower distress prices. The company's competitive position in relation to this fuel is not similar to the coastal areas where large quantities of foreign heavy oil imports have been received and burned during the past few years.

Although oil may not be competitive with coal, there may be times when the utility is justified in paying a premium to burn this fuel in limited quantities to increase steam generation, coal preparation, or handling capacity for peak demands. The additional fuel expense for peaking operation may be more than justified when considering the investment required to install additional equipment that might be needed for only short periods during the year. At two of the company's plants, oil burning facilities have been installed, and it is expected that this fuel will be burned in limited quantities when needed for peak load demands.

Although the industrial market price for natural gas is not normally competitive with coal, rates for off-season supply might bring natural gas into the picture at various times. When gas is supplied on this basis, the contract usually contains a provision that the gas may be cut off after a stipulated notification period, and it is necessary to maintain a firm coal supply with a resultant decrease in the amount of saving in operating expense that can be credited to the gas.

With increased oil imports, extension of natural gas lines into new areas, greatly increased coal productivity due to mechanization, the competition between various fuels has become keener. The amount of regulation these various fuel industries experience as to price and end use of these fuels will affect their competitive relationship, and it is just as difficult to forecast fuel trends as it is other business trends under present conditions.

Coal Preparation in England And Holland

by John Griffen

Methods of coal preparation in England, including usage of American units such as the Chance sand flotation process and Denver flotation cells, are compared with methods used in the United States. Problems of the coal industry in Holland are summarized.

OF the western European countries, only England has made any extensive use of equipment developed initially by the coal preparation industry of the United States. About 20 years ago, the Chance sand flotation process for cleaning coal was introduced in England, and it has had a fairly wide adoption, particularly in the South Wales coal fields. In recent years, particularly since 1946, a considerable number of Denver flotation cells have been installed throughout the English coal fields for the cleaning of slurry. Until the advent of the Denver cells, the flotation of coal slurries in Western Europe had been done largely with the Mineral Separations cell or its modifications. Kleinbentik of Dutch State Mines had developed a cylindrical cell used in Holland and occasionally in Belgium and France.

In England, the establishment of the National Coal Board to control the planning and operation of all coal production has retarded somewhat modernization of properties. A considerable period of study was required before definite long-range plans could be formulated. It was soon recognized that stopgap measures were needed in many cases to bridge the period until final plans could be developed and consummated.

One of the stopgap problems in coal preparation was providing plants of small and medium capacity that could be used for a few years at one site and yet could be moved economically to another site so as to reduce depreciation charges per year and per ton. Such plants are being installed but the most satisfactory answer probably has not yet been found. One such installation uses a Norton Baum jig to wash 6 in. to 0. The equipment is in a steel structure rather than in a reinforced concrete frame with brick curtain walls, which is the normal structure for permanent plants.

Since England has between 700 and 800 preparation plants for an output of 200 million tons per year, one of the long-range objectives is a consolidation of mine output which will require fewer coal

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preparation plants since each will have a larger capacity than the usual plant. The ideal plant capacity had not yet been fixed but, for the present, cleaning plants of about 800 tons per hr seem to be favored. Actually, these are usually two plants of 400 tons per hr input in one structure. This duality is often dictated by the fact that several seams are mined producing coals of different qualities that must be prepared separately in the sizes above slack for different markets.

The four phases of coal preparation in which England has made further progress than the United States are:

1. Mechanical cleaning of large coal to eliminate picking labor.

2. The use of heavy media processes to clean difficult coals and particularly to produce two coal products, a very high quality first grade coal for special purposes such as railway fuel, London house coal and the export market, and a medium quality coal for ordinary uses.

3. The cleaning of slurries by froth flotation.

4. The use of starch and other coagulants on the feed to thickeners so as to completely clarify washery waste water before re-use and to prevent stream pollution.

There are a number of plants regularly cleaning 8 in. to 2 in. raw coal, thus reducing the number of pickers required to clean the lump. At one plant, the +8 in. lump passes over a picking table where about three pickers remove rock larger than about 8 in.; the remainder passes under a pick breaker that breaks coal and bone to about −12 in., although coal lumps larger than 12 in. enter the bath. The large coal then joins the 8 in. to 2 in. size and is cleaned in heavy medium baths. In the first bath, coal is separated at about 1.47 sp gr and final refuse at about 1.70 sp gr. The middlings are crushed −2 in. and added to the raw 2 in. to 0 for subsequent cleaning. The coal product of the first bath is recleaned in a second two-product bath at 1.33 to 1.37 sp gr making two qualities of coal:

First grade, +4 in., 5.0 pct ash;
First grade, 4x2 in., 4.5 pct ash;
Second grade, +2 in., 15.0 pct ash.

This coal has rather high inherent ash content.

Heavy medium plants treating coals of lower inherent ash content are producing washed coal as follows: 5 in. to 3 in. round, 1.7 to 2.2 pct ash; 3 in. to 2 in. round, 1.9 to 2.8 pct ash; 2 in. to 1 in. round, 2.2 to 2.9 pct ash; 1 in. to ½ in. square, 2.7 to 3.2 pct ash.

In the cleaning of slurry, not only is froth flotation widely used, but the slurries are generally coarser than in this country. Slurry −½ mm or 28-mesh is usual, and with the bituminous coals of South Wales and the gas coals of Durham, which are quite easily floated, material as coarse as 1/20 in. or nearly −10-mesh Tyler standard screen scale is handled. The South Wales float coal is as low as 3.0 pct ash.

Although closed water systems and the use of coagulants are not by any means universal, the larger, newer plants, even those built just before or during World War II, were generally so operated, and in every case the thickener overflow was crystal clear.

The English coal market has been accustomed to nut and larger sizes of extremely low ash content, 4 pct or less, which were readily produced from the excellent seams of the past. The exhaustion of those seams and the changes in mining methods are resulting in run-of-mine output much more difficult to prepare, but all efforts are directed toward the building of preparation plants that can continue to meet these rigid standards of high quality products in these larger sizes. The requirements for slack and nut-slack are not so rigid, and in most cases the cleaning of these sizes is done by methods used in the United States.

The coal industry of Holland, in marked contrast to that of England and the United States, is on a small scale, and there are very few coal producers. In 1938 the Dutch coal industry produced 13½ million metric tons. In plants operated by the industry, part of this coal was processed into 2.4 million metric tons of coke and 1.2 million metric tons of briquets. As the result of the war, coal output dropped to 5 million metric tons in 1945 but by 1948 had increased to 11 million metric tons. The changes in production of coke and briquets roughly paralleled that of coal.

The government-controlled Dutch State Mines, which operates four mines, produces 60 pct of the output. Four private companies, which operate eight mines, are under a certain amount of government control.

The four Dutch State Mines properties with an annual output of about 8 million metric tons are large properties, and, as the seams are generally deep, up to 1000 m of cover, mining is difficult and expensive and the run-of-mine coal is quite dirty, containing 30 to 35 pct reject.

Because of limited reserves, the high cost of coal and its importance to the economy of Holland, the Dutch State Mines are carrying on extensive research on mining and preparation problems and have large laboratory facilities and research personnel.

In preparation, the Dutch State Mines has lead in the development of heavy medium processes—the Barvoys, Loess, Driessen—and now the Dutch State Mines process using flotation tailings or ground washery refuse as medium solids. Another excellent heavy medium process, the Tromp, was developed at Domaniale, one of the private mines. The Tromp process utilizes fine magnetite, mill scale, or other heavy solids, which may or may not be magnetic, and recovers and reconditions the medium solids by gravity rather than magnetic means.

Much of the effort of the Dutch State Mines in developing heavy medium processes has been directed by the desire to use medium solids readily available in Holland. The barytes required for the Barvoys process must be imported from Germany. Magnetite has to be imported from Sweden. This probably explains the interest in loess, which is plentiful in Holland. However, its technical limitations are focusing attention on flotation tailings and ground washery refuse as medium solids.

Since coal in Holland is so valuable, preparation plants recover high ash middlings, and the refuse rejected is almost pure rock, usually analyzing 75 to 85 pct ash. In addition to producing its own electric power, the Dutch State Mines operates a large generating station which supplies electricity to the National Electric Grid.

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aime NEWS

Columbia Section Presents Program At Northwest Mining Assn. Convention

The Columbia Section, AIME, was an active participant in the 56th annual convention of the Northwest Mining Assn. Convention in Spokane on Dec. 1 and 2, presenting lively sessions on rock drilling methods, the application of geology to mining, and on design and operation of small concentrating plants. AIME President D. H. McLaughlin attended the meeting, addressing the opening day's luncheon on the subject of taxation and legislation affecting the mining industry. Howard P. Sherman, Chairman, Columbia Section was in charge of the AIME contributions to the convention.

A novel session, in the form of a round table consisting of various experts, tackled the problem of how to build a 200-ton flotation mill with certain factors and requirements as given. These included: ore, gangue, required grind, reagents, cleaning, and an absence of slime interference. The whole session was tape recorded, and the information will be transcribed and edited by the speakers with a view to presentation in the form of a technical paper. Norman Sather, Hecla Mining Co., discussed the site; W. W. Staley, University of Idaho, spoke on bins; L. S. Prater, Idaho Bureau of Mines, contributed his views on crushing; H. March, American Zinc, Lead & Smelting, discussed grinding and classification; and J. C. Crampton, of Pend Oreille, L. A. Grant of Day Mines, A. McKinley, Sidney Mining Co., spoke on flotation, filtering, and general arrangement, respectively. F. H. McKinley, Bunker Hill & Sullivan, and C. Y. Garber presided over the session, which drew an attendance of 150.

The rock drilling session, presided over by C. A. R. Lambly, Pend Oreille, and J. J. Curzon, Howe Sound, heard papers on drilling at Bunker Hill, Pend Oreille, Howe Sound, and a talk on the new Ingersoll-Rand Jackleg. These were presented by E. B. Olds, L. M. Kinney, W. S. Phillips and J. C. Heaslip, respectively. All papers have been submitted to AIME for consideration as possible technical papers.

One hundred and fifty convention-goers attended the session on geology, which was headed by A. E. Weissborn of the Geological Survey in Spokane. S. W. Hobbs of the Survey presented a paper on basic data and research, E. C. Stephens of Anaconda spoke on exploration geology, with T. Gillingham of Bunker Hill and J. L. Leonard, Spokane consultant, covering the Coeur d'Alene and Metaline districts, respectively.

The convention heard H. W. Marsh of the Idaho Mining Assn. assert that the scientific world is now looking toward the area between Desert Falls and Arco, where a new atomic reactor plant is expected to start operations shortly. He also noted that the Bradley Mining Co.'s operation in Idaho is producing 96 pct of the nation's antimony, and that Calera Mining Co. is completing a mill which will permit production of strategic cobalt.

The tremendous expansion, unparalleled in its long history, characterizing the mining industry in Canada's Pacific Northwest, was outlined by F. E. Woodside of the British Columbia and Yukon Chamber of Mines. The prevalent feeling of optimism has not been matched since the turn of the century when the Kobtenay and Rossland camps flourished and gold was discovered on the Klondike, he said. At least 31 companies have been organized recently to develop base metal, and twelve new mills are under construction or in the planning stages, Mr. Woodside noted.

New York Section Student Paper Award

Arnold Goradesky was recently awarded the prize for the best paper in the New York Section contest of the nation-wide Student Prize Paper Contest. Each year the New York Section gives a prize of $50 for the best student paper from one of the local Student Chapters. Mr. Goradesky's paper, "A Study of the Preferred Orientation in Cold-Rolled Aluminum," was written while he was an undergraduate at New York University. He is currently undertaking graduate studies in the metallurgical department.

AIME Preliminary Budget Reviewed

At their meeting on Dec. 20, 1950, the Executive and Finance Committees reviewed the preliminary budget of the Institute for the coming year which had previously been prepared by the Finance Committee. It was pointed out that the most difficult item to estimate at this time is advertising income, because 1951 contracts will not be in hand before February. However, indications were that advertising income could be placed at $131,500, compared with an expected $104,000 in 1950. MINING ENGINEERING is expected to yield $63,000, the JOURNAL OF METALS $45,000, and the JOURNAL OF PETROLEUM TECHNOLOGY $23,500. Total income in this preliminary budget is $496,000, and total expenses approximately $482,000. A final budget will be presented later.

Some curtailment of AIME income is likely to result from another action of the Directors at this meeting; it was voted that no more orders should be accepted for shipment of AIME publications to the USSR, Poland, Czechslovakia, or Romania. Heretofore, almost 300 annual subscriptions for Institute journals have been booked for shipment to these countries, to say nothing of numerous bound volumes.

Wisconsin Student Chapter Meets

Earl E. Hunner, executive consultant for the M. A. Hanna Co., Duluth, was guest speaker at the recent dinner meeting of the Mining & Metallurgy Club at the University of Wisconsin. More than 80 students, AIME members, and guests attended. Mr. Hunner's informative talk covered the rapid use of known iron ore reserves and possible future supplies of local and foreign ores that will be commercially available and needed, if the U. S. is to continue making half of the world's steel.

ECPD Annual Meeting Held

Engineers Council for Professional Development held its annual meeting at the Tudor Arms Hotel, Cleveland, on Oct. 20-21. Harry S. Rogers, president of the Polytechnic Institute of Brooklyn, was reelected chairman of the Council, and L. F. Grant, field secretary of the Engineering Institute of Canada, vice-chairman. William N. Carey succeeds C. E. Davies as secretary, with Edward H. Robie as assistant secretary. C. E. Lawall, Curtis L. Wilson, and James R. Cudworth represent AIME on the Council. All were present at the Cleveland meeting, as were W. R. Chedsey, James L. Head, D. R. McKeithan, and L. E. Young, of the AIME.

W. F. Thompson became chairman of the Guidance Committee; S. C. Hollister continues as chairman of the Education Committee; A. C. Monteith remains chairman of the Training Committee; R. H. Barclay continues as chairman of the Recognition Committee; William F. Ryan became chairman of the Ethics Committee; and Walter E. Jessup continues as chairman of the Information Committee.

In the mineral industry field, the following curricula were reported as having been accredited for the first time in 1950: Geological Engineering, Arizona, Idaho, Minnesota, Pittsburgh, and South Dakota School of Mines. Mining Engineering (geology option), Missouri School of Mines. Metallurgical Engineering, Arizona and Wayne. Petroleum Engineering (petroleum and natural gas), Texas College of Arts and Industries.

A new record was made by ECPD in the prompt printing and distribution of its annual report of 53 pages. This report, which contains among other things a complete list of accredited curricula in engineering schools and technical institutes, is available for 50c from the Secretary of ECPD, 29 W. 39th St., New York 18. Stamps acceptable.

John Markle Society Holds Meeting

J. F. Libsch, guest speaker, discussed induction melting at the recent meeting of the John Markle Society, Lafayette College. Mr. Libsch is assistant professor of metallurgy at Lehigh University. A motion picture depicting the mining of iron ore, fabrication and use of stainless steel tubing in the oil industry was also shown. Initiating the policy of having a student speak at each meeting, Robert Leighton, '52 mining engineer, presented experience in prospecting and exploration with the U. S. Bureau of Mines.

ASME Dues Raised

By a vote of at least two thirds of the voting members, as provided by the bylaws, the American Society of Mechanical Engineers has voted to raise its dues by $5 effective October 1951. The new rate is $25 per year for Fellows, Associates, Members, and Junior Members over 33 years of age; $20 for Junior Members 30 to 33; and $10 for Junior Members less than 30 years of age.

Local Section Affiliation

Many AIME members are not clear as to their affiliation with Local Sections of the Institute. In all, there are 43 Local Sections in the United States, plus three others in the Philippines, Mexico, and Brazil, respectively. Each of these Local Sections covers a certain geographical area. The only areas not included in Local Sections, as currently constituted, are New York State outside of a radius of fifty miles of New York City; a part of eastern Pennsylvania and southern Delaware, North and South Carolina, Iowa, Nebraska, North Dakota and the eastern part of South Dakota, and northern New Mexico. An AIME member is automatically considered a member of the appropriate Local Section in whose territory he maintains a mailing address. Some Local Sections, however, have local dues, essentially to cover the cost of printing and mailing notices of meetings, and only those who pay these local dues are considered active members of the Section.

It sometimes happens that a member may be more interested in the programs of a neighboring Section than in those of his own, or may wish to receive notices of meetings of another Section in whose territory he may often be. In such cases he may ask to join other Local Sections than his own. It is only necessary to write to the Secretary of the Section, whose name and address will be found on pages XXIV to XXXI of the current 1950 Directory, and ask to be included in his mailing list. He may likewise ask the Secretary of his own Local Section to have his name dropped from the mailing list, if he is not interested in the subjects of their meetings.

Civil Service Positions Open

A limited number of vacancies exist in U. S. Air Force headquarters, Pentagon, Washington, D. C., for mining and metallurgical engineers who also possess photo interpretation experience or potential. Photo intelligence specialists GS-9, $4600 per annum, starting salary through GS-12, $6400 per annum, starting salary. Civil Service grades assigned will depend largely on education and/or equivalent experience in the field of mining engineering and/or metallurgical engineering. Inquiries and requests for required Civil Service application forms should be made to the following: Photo Intelligence Section, Reconnaissance Branch, Directorate of Intelligence, Headquarters, U. S. Air Force, Washington 25, D. C.

Southeast Mineral Symposium Planned

The Southeastern Mineral Symposium will be held at Emory University, Atlanta on Mar. 29-31. The Southeastern Geological Society will join with University of Kentucky, University of Tennessee, Vanderbilt, and Emory University. A series of papers discussing geological problems in the southeast United States will be presented and field trips have been arranged. For reservations write to Arthur C. Munyan, Dept. of Geology, Emory University, Atlanta, Ga.

Engineering Foundation Reports on Research Projects

Fourteen research projects were being sponsored by the Engineering Foundation in the year ended Sept. 30, 1950, four of them being in turn sponsored by the AIME. These four were No. 32, Alloys of Iron Research; No. 97, Diffusion in Steel; No. 98, Mechanical Properties of Binary Alloyed Ferrites at Low Temperatures; and No. 104, Comminution. The grants to the AIME projects totaled $7000. AIME members wishing to obtain financial support for research projects should apply to the technical director of the Foundation, Frank T. Sisco, an AIME member. In general, grants are made only if industry thinks enough of the project to assist in the financing. The chairman of the Foundation is B. A. Bakhmeteff; A. B. Kinzel serves on the executive committee, Gail F. Moulton and E. C. Meagher are trustees, and E. R. Kaiser and W. M. Peirce, AIME representatives.

Mexico Section Chairman

Alfredo Terrazas, chairman of the Mexico Section is "working with enthusiasm in the formation of the Mexico Section" and is looking forward to making "the 1951 convention a pleasant success for all comers." Mr. Terrazas has been actively engaged in mining for 25 years for both English and American companies and has been a consultant for 14 years.

Zay Jeffries Elected Honorary Member of AIME

Zay Jeffries, a retired vice-president of the General Electric Co., Pittsfield, Mass., was elected to Honorary Membership in the AIME. This group is limited to 20 living members, and only 80 engineers and scientists have been so honored since the Institute was founded in 1871. With Dr. Jeffries' election, but one vacancy remains.

Dr. Jeffries has been prominent in metallurgical research in the diverse fields of theoretical metallurgy, aluminum alloys, and powder metallurgy. He has also been outstanding in administrating industrial research and development. His professional and administrative talents and efforts have made major contributions to the development of the tungsten filament lamp industry, to the establishment of the sintered carbide casting tool, and to the development of new and improved industrial aluminum alloys.

He long has been a member of AIME, and a professionally active one, having contributed many professional papers and participated actively in its metallurgical discussions for over 30 years. He has been both the Institute of Metals Annual Lecturer (1924) and the Iron and Steel Div., Howe Memorial Lecturer (1930), and in 1927 was the James Douglas Medalist. In 1936, he was awarded the John Fritz Medal, given by the four Founder Societies "for notable scientific or industrial achievement."

Library Photoprint Service Revised

To conserve time and the inconvenience of trying to locate material for photoprinting, the Engineering Societies Library has revised this service. For material at the library, copies can be supplied as negative prints, white on black, for 40c, minimum charge $1 per order. Any two facing pages which together measure not over 11x14 in. can be taken on one print. Larger material will require one print per page. If material is not in the library, search will be made on request and if available elsewhere there will be the regular charge of 40c a print and an additional charge of $3 service fee for locating the article. There will be no charge if the material cannot be located.

Members of the AIME, ASCE, ASME, and AIEE who order work for their personal use will receive a discount of 20 pct on the fee for locating the article and a reduction of 5c on each photoprint.

J. L. Head Elected Chairman of Library Board

James L. Head, an AIME Director, has been elected chairman of the Library Board of United Engineering Trustees, which administers the Engineering Societies Library. He succeeds J. S. Thompson, who has just completed a two-year term. Frank T. Sisco, AIME, recently appointed as a member of the Board for a four-year term ending in 1954, is chairman of the administrative committee of the Board, and James Douglas, also AIME, is on the budget committee.

Additions to the Library in the last year totaled 1958 books, 63 searches, and 747 maps. Currently the Library contains 185,766 items, valued at $439,000. Visitors for the year ending Sept. 30, 1950 totaled 22,283, compared with 22,921 in the previous year, and nonvisitors served were 14,618, compared with 15,908 in the year before. The principal services were photostating, microfilming, searches of the literature, translations, lending books, and answering telephoned and written requests for information.

To the support of the Library, the Founder Societies contributed $50,000. The AIME share for the calendar year 1948 was about $12,400, and in 1949, $9300. However, about $3300 of this amount in each year was furnished by the James Douglas Library Fund, whose income is specially earmarked for this purpose. This left the net contribution by AIME in 1948 as $9114, and in 1949 $6049, or 59c and 37c per member, respectively.

Change of Status Automatic For Junior Members on 33rd Birthday

Junior Members reaching the age of 33 are now required to change their status to Associate Member or Member. They are elected automatically to Associate Membership unless they apply for the higher professional grade, which requires six years of experience in the mineral industry, three years of which must be in positions of responsibility. To make transition as easy as possible in view of the requirement that an initiation fee be paid by either Associate Members or Members, the Board of Directors at its Nov. 15 meeting voted that the initiation fee for Junior Members so transferring be billed in four annual installments of $5 each. If such Junior Members are in arrears for dues, they may also pay such arrears in four annual installments.

Mining Geologists Needed

The U. S. Geological Survey's new responsibilities under the Defense Production Act of 1950 will require the addition of mining geologists for field and office work on metallic and non-metallic mineral deposits. Field work will consist of making mine examinations and appraisals in connection with applications for loans, purchase contracts, and other encouragement under the Act. Office work will be done in Washington, D. C. and will consist largely of reviewing and analyzing field appraisals and other data, and making recommendations in cooperation with the Bureau of Mines, Defense Minerals Administration, and other agencies for expansion of mineral production.

Openings are available at grades of GS-9 ($4600 per year) to GS-13 ($7600 per year). A minimum of five years post-bachelor experience, preferably in mining geology, is required for these positions. For further information write to the Chief, Mineral Deposits Branch, U. S. Geological Survey, Washington 25, D. C.

MED Annual Meeting Luncheon

The luncheon sponsored by the Mineral Economics Div. will be held at 12 o'clock on Tuesday, Feb. 20. This will feature a forum discussion of the Institute's recently liberalized policy on controversial matters. At its June 22, 1950 meeting, the Board passed a compromise resolution which reaffirmed the stand made in 1933 prohibiting the Institute from adopting an official position on subjects pertaining to the economic welfare of the mineral industry, both here and abroad. At the same time, the resolution stated, "This, however, shall not be regarded as a rigid prohibition against an expression of opinion by the Board on matters pertaining to the mineral industries that are of vital interest to the nation in times of danger."

Institute officials will start the ball rolling by giving an interpretation of the revised resolution, with comments on methods for taking such action as is permitted under present policies. There will be ample opportunity for questions and floor discussion by those agreeing or disagreeing with the policy as it now stands.

Here is a chance to hear and participate in an open discussion of a matter that is vital to the future of the Institute and to the nation—discussed officially in the past only at meetings of the Board.

President McLaughlin Visited 23 States, 31 AIME Local Sections During Year as President

Donald H. McLaughlin, AIME President in 1950, literally burned up the roads and the air lanes last year visiting Local Sections and student groups from coast to coast. Dr. McLaughlin racked up the impressive total of 31 visits to Sections, and nine visits to student groups, in 23 states and Washington, D. C. This does not, of course, include his trips to New York for AIME Board meetings. The President's visits, pinpointed on the map above, were as follows: Arizona, Black Hills, Boston, Carlsbad, Chicago, Colorado, Columbia, Coeur d'Alene Subsection, Connecticut, East Texas, El Paso, Gulf Coast, Lehigh Valley, Minnesota, Montana, Nevada, New York, North Pacific, North Texas, Ohio Valley, Oregon, Pennsylvania Anthracite, Permian Basin, Pittsburgh, St. Louis, San Francisco, Southern California, Southwest Texas, Utah, Washington, D. C., and Wyoming. Student Societies included: Wisconsin, MIT, Arizona, California, Michigan, Montana, Lafayette, Lehigh, and South Dakota.

Two other staff members, AIME Secretary E. H. Robie, and John V. Beall, Editor of MINING ENGINEERING and Eastern Secretary of the Mining Branch, made material additions to the number of dots on the map above. Mr. Robie visited 16 states and Washington, D. C., for a total of 19 Sections during the year. These were: Black Hills, Chicago, Cleveland, Colorado, Columbia, Coeur d'Alene Subsection, Lehigh Valley, Minnesota, Montana, Nevada, New York, Oregon, North Pacific, Pittsburgh, St. Louis, San Francisco, Utah, Wyoming, and Washington, D. C. Mr. Beall, who is also Secretary of the Student Relations Committee, dropped in on eight Sections and four student groups, spreading his activities over eight states. He visited: Chicago, Colorado, Colorado School of Mines, Columbia School of Mines, Southeast, Utah, Southern California, Arizona, Morenci Subsection, Southwest New Mexico, University of Arizona, New York University, and City College of New York.

Roy E. O'Brien, newly appointed Western Secretary of the Mining Branch has stacked up a record of visitations which spread from coast to coast in the four months he has been employed by the Institute. Roy makes his headquarters at 808 Newhouse Building, Salt Lake City, Utah, and keeps close contact with AIME affairs and the industry in this mining center. He spent a 10-day orientation period at headquarters in New York early in October 1950. In visiting the following Local Sections and Student Chapters, Roy also stopped to talk with AIME members and visit mining operations in and around his points of call. His itinerary included the following Local Sections and Student Chapters: Columbia, Coeur d'Alene Subsection, University of Idaho, Montana School of Mines, South Dakota School of Mines, Utah, University of Utah, Colorado, San Juan Subsection, Colorado School of Mines, St. Louis, St. Louis University, Missouri School of Mines, Tri-State, Pittsburgh, and New York.

Industrial Minerals Division Holds Successful Two-Day Regional Meeting

Geologists, mining engineers, chemists, plant managers, and railroad men from 9 states and Canada were on hand to contribute papers, comments and discussions at the recent Regional Meeting of the Ind. Min. Div. in Norman, Okla. Fourteen papers were presented on mineral development in the southwestern states of Kansas, Oklahoma, New Mexico, Texas, Louisiana, Missouri.

The keynote paper, by H. B. Foxhall, director, Arkansas Geological Survey, emphasized the 300 pct increase in dollar value of mineral resources produced during the 1939-48 period, and the fact that the southwestern region contributed about 30 pct of the mineral wealth in the U.S. in 1948. Other papers, as listed in the September issue of MINING ENGINEERING, were presented by: R. H. Dott, W. E. Ham, G. W. Chase, G. W. Wunder and Paul Allen, J. T. Lonsdale, A. G. Wolf, W. I. Weisman and R. C. Anderson, N. F. Williams, C. Perkins, E. K. Nixon, G. A. Muilenberg, E. Blessing, and H. D. Miser.

A trip to the Wichita Mountains was conducted by G. W. Chase, who recently completed investigations in that area for the Oklahoma Geological Survey. W. E. Ham conducted a two-day trip to the Arbuckle Mountains after the meeting, visiting various quarries and plants. The Lawrence Quarry of the Ideal Cement Co., where a new $110,000 Marion electric shovel is quarrying high-calcium Fernvale limestone for the manufacture of cement, was one of the trip's high points. The 17 members who took the trip also saw quarrying and flotation of glass sand at the Mid-Continent Glass Sand Co., at Roff, Okla., as well as operations of the Pennsylvania Glass Sand Corp. at Mill Creek and the dolomite quarry and crushing plant of the Rock Products Mfg. Co. near Troy. The Southern Rock Ashphalt Co. and Dolese Bros. Co. operations were also on the agenda.

Northwest Mineral Industry Institute to Meet

The Northwest Mineral Industry Institute will meet Feb. 15 on the University of Washington campus in Seattle. The topic selected for discussion this year is "Critical Ceramic Raw Materials."

Registration is at Guggenheim Hall at 1:00 pm and the program of papers and discussion will begin at 2:00 pm. Larry Penberthy, Penberthy Instrument Co., Seattle, will speak on "Glass Making Materials—Why and Where From." K. T. Cleveland, director of research and development,

Philadelphia Quartz Co. of California, will speak on sources of silica, and H. J. Kelly, Northwest Experiment Station, U. S. Bureau of Mines, will speak on fluxes obtained from the dry lakes of central Washington.

The second portion of the afternoon meeting will be devoted to the refractories industry. E. H. Whitney, Gladding, McBean & Co., will speak on "Problems in Refractory Raw Materials." C. Phillips Purdy, Jr., Div. of Mines & Geology, Washington Dept. of Conservation & Development, will present a paper on refractory clays in the state of Washington.

Following a dinner at the Union Bldg., the final session will be held jointly with the Pacific Northwest Section of the American Ceramic Society and the North Pacific Section, AIME. Louis Koenig, assistant director of research, Stanford Research Institute, will speak on critical ceramic materials in the West and ceramic research in the West.

Over 400 Attend Recent Arizona Section Annual Meeting

The Arizona Section, AIME, held a highly successful, well-attended annual meeting on Nov. 27, in Tucson's Pioneer Hotel. Registrations during the day totaled 454, consisting of 159 members, 101 student associates, and 194 guests and guest members. All five divisions—Underground Mining, Smelting, Ore Dressing, Open-Pit Mining, and Mining Geology—participated and presented a wide variety of papers.

Mining Geology

The Mining Geology gathering was presided over by Louis E. Reber, Jr., and at its business session the group elected Harrison Schmitt and Robert Hernon, both of Silver City, N. Mex., as Chairman and Secretary, respectively, for 1951. The Division's technical session heard L. A. Smith's paper on "The Geology of the Commonwealth Mine, Pearce, Ariz.", and this was followed by C. A. Anderson's outline of work being done by the Geological Survey in the southwest. Both papers provoked considerable discussion. Among those attending was Donald H. McLaughlin, AIME President in 1950.

Underground Mining

H. I. Ashby presided over the Underground Mining Div. session. W. P. Crawford of Bisbee, Ariz., was elected Chairman of the Division for 1951. A "Report on Circular Steel Drift Sets at Miami Copper" was offered by J. W. Still, general superintendent at Miami. A. J. Zinkly, assistant general superintendent, Iron King Branch, Shattuck Denn Corp., spoke on the use of carbide insert bits at the Iron King mine. Most of those present seemed to feel that throw-away detachable bits made for cheaper hole costs in all but the hardest and most abrasive rock.

Open-Pit Mining

John A. Lentz, Jr., was elected Chairman of the Open-Pit Mining Div. for 1951, at a meeting presided over by A. P. Morris. Mr. Lentz is mine superintendent for Phelps Dodge at Ajo. The 106 members, students and guests attending the Division's technical session heard seven interesting papers on open-pit mining problems and practices. They were: "Use of Torque Converters in Pit Truck Haulage," by F. Byers, superintendent, Isbell Construction Co., Ray, Ariz.; "Radio in Pit Communication," by G. J. Ballmer, superintendent of mines, Kennecott Copper Corp., Chino Mines Div.; "Two-Way Radio Communication for Mine Use," by J. U. Larson, general mine foreman, Phelps Dodge Corp., Morenci, Ariz.; "Sampling and Assaying, Inspiration Copper Co.," by J. L. Carne, assistant chief mine engineer; "Sampling and Ore Control at the New Cornelia Mine," by J. W. Newett, chief engineer, Phelps Dodge Corp., Ajo, Ariz.; "Problems of Grade Control at Castle Dome," by J. J. Spencer, Miami, Ariz.; "Ore Control and Churn Drill Prospecting at the Cananea Open Pits," by F. M. Leonard, Jr.

Ore Dressing

H. F. Adams opened the Ore Dressing Div. session with an informal talk on the leaching in place project at Inspiration. This was followed by G. H. Roseveare's talk on the Dorrclone classifier and its possible application, and by H. Keyes' comments on sewage treatment by the city of Phoenix. C. H. Curtis was elected Chairman of the Div. for 1951.

Smelting

The Smelting Div. heard a progress report on a slag project being carried out at the University of Arizona. The work was based on the theory that slags are composed of certain mineral phases and that such phases should be considered in the composition of smelter changes. E. J. Caldwell, superintendent, Magma smelter, reported improved results in furnace operation on application of this theory. Reelected as Chairman and Secretary of the Division for 1951 were E. J. Caldwell and J. B. Cunningham.

A cocktail hour and dinner followed the all-day sessions. AIME President McLaughlin was the principal dinner speaker.

All those outside the Section interested in attending future functions of the Arizona Section should send a card with name and address to John C. Loving, c/o M. F. McDonald, Naco, Ariz. Their names will be placed on the mailing list to receive news notices.

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Young men for sales work by manufacturer of heavy machinery. Knowledge of crushing, milling and processing as related to mining and aggregate and cement production advantageous but not necessary. Qualified applicants afforded opportunity for rapid advancement. Give full particulars: age, education, previous experience in these industries and present position. All replies confidential. Our Sales Department has been advised of this advertisement.

Box No. B-5, Mining Engineering

When Changing Your Address

When notifying AIME headquarters of a change of address, or of company position or affiliation, *please mention the Branch of the Institute to which you belong*—Mining, Metals, or Petroleum. This will make for a more expeditious handling of the change and will facilitate the preparation of various reports.

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Drift of Things . . . . . . as followed by **Edward H. Robie**

THOUGH nothing is as important to personal, national, and world well-being as recent international, political, and military developments, we have not lately made any comment on them. We have never been east of Cape Cod, west of the North Pacific coast, north of Saskatoon, or south of Key West, so perhaps our point of view is too circumscribed to be worth offering. However, an excellent guide book to Paris was written by a man who had never been there.

What should the United States do? What should the United States have done? Plainly, those who ran the world before World War II did a sorry job of it. Those who have been running it since that war ended have done even worse, for here we are confronted with a strong possibility of an even more terrible era of devastation and blood-letting. But we have yet to hear any of the world's leaders apologize for their ineptitude. Any evidence of a contrite spirit seems to be missing. Worse still, the voting peoples seem complacent and not moved to demand a change.

Hoover Statement

Of recent public pronouncements by people in the public eye, that of our own Herbert Hoover on Dec. 20 over the Mutual Broadcasting System makes the most sense to us. At 76, Mr. Hoover spoke firmly and clearly and, of course, his background of experience in America, Europe, and the Far East commands the highest respect. Two months before, he had opposed further military or economic aid to Europe until it set up a "united and sufficient" European army, and he urged reorganization of the United Nations without the Soviet Union and its satellites.

In his latest speech he expanded on his former statements. He first surveyed the global military situation, pointing out that the Communists in Europe and Asia have over 300 trained and equipped combat divisions, with more than 30,000 tanks and 10,000 tactical planes, though their long-range air power is limited and their sea power confined to submarines. Some day, he said, "the Communistic empire will go to pieces. But in the meantime they are cannon fodder." Facing the Communists in the Far East are the already defeated Koreans, and perhaps 12 combat divisions in addition. Among our friends, only Formosa and Turkey, in Asia, have any important military strength. Among the European Continental countries, Mr. Hoover estimates something less than 20 combat divisions, with disunity and a feeble will to defend themselves. The British commonwealth has perhaps 30 combat divisions, with a good air force and a superior navy. Here in the U. S. we are planning 30 combat divisions with a gigantic air force and navy.

With this situation, Mr. Hoover can see no hope of defending Asia or continental Europe against the Communist horde by land forces, should the Communists decide to attack, even though the non-Communist countries had the will and means to defend themselves, which they do not have. For the U. S. to undertake to fight the Communist countries in Asia and continental Europe practically single-handed is sheer folly. "That would be the graveyard of millions of American boys and would end in the exhaustion of this Gibraltar of Western civilization. Even were Western Europe armed far beyond any contemplated program, we could never reach Moscow. The Germans failed with a magnificent army of 240 combat divisions and with powerful air and tank forces as contrasted with the 60 divisions now being talked about."

New Frontiers

So Mr. Hoover proposes that we defend Western civilization by arming our air and naval forces to the teeth rather than to send a land army in a futile mission to continental Europe or Asia. Our eastern frontier would be in Britain; our western on Japan, Formosa, and the Philippines, provided they were willing to try to defend themselves with our help. Presumably we would see that Communist aggression was stopped everywhere in the Americas.

Mr. Hoover has been accused of preaching isolationism, but surely the frontiers indicated are sufficiently broad to emphasize our desire to assist other countries. He has been accused of being a defeatist, but he offers a realistic program that has much more hope of success than does a more extended policy of spreading our military and economical policy so thinly that defeat would be practically certain. He has been accused of scuttling the Atlantic Charter and the North Atlantic Treaty, but nothing in those agreements commits the United States to undertake the defense of Europe on a scale far greater than the European countries are willing to assume.

The United States cannot be the omnipresent policeman throughout the troubled non-Communist world. That, thinks Mr. Hoover, is the job of the United Nations. The United States should not have had to provide 90 pct of the military force in Korea. Other United Nations countries at least could have provided men, if not munitions. If they are unwilling to assume their proper share of the burden, the United States must be realistic and pull in its lines a bit. Mr. Hoover suggests four things for the United Nations to do: (1) Declare Communist China an aggressor. (2) Refuse admission of this aggressor to its membership. (3) Demand that each UN member country cease furnishing or transporting supplies of any kind to Communist China that can aid in its military operations. (4) Pass a resolution condemning the infamous lies about the United States.

UN Unity Necessary

We think it is about time that the countries opposed to Russia's policies get together and make the United Nations work. There is still a good chance for this organization to be effective if the Russian shackle on its activities is removed. A UN army, navy, and air corps that will be able to stand off Russia is needed, to which every member nation should contribute. It should operate under codified international law, defining, among other things, what is meant by aggression. No nation should have the right to veto any action that it might consider to be to its disadvantage, and yet this veto power was one of the things that the United States originally insisted on having included in the UN Charter.

The United States should temper its crusade for the institution of our brand of democracy and freedom throughout the world. It works to our general satisfaction but it probably would not function satisfactorily in many other countries—Latin America, for example. It is right that we are aiding even Communist Yugoslavia. If a country minds it own business and does not molest its neighbors, its form of government should be its own affair.

Personals

Eugene M. Adrian, Jr. is now employed as a surveyor for the Mountain Seismic Co., Bridgeport, Neb.

G. J. Bilstein is manager of the Matilde lead and zinc property for Mauricio Hochschild S.A.M.I., La Paz, Bolivia. He was previously assistant mine foreman for Cia. Huanchaca de Bolivia.

Arthur G. Bigley has been appointed manager of mines, Anaconda Copper Mining Co. **Edward I. Ronouard, Jr.** has been made general superintendent of mines, succeeding Mr. Bigley. **T. Charles Wise,** superintendent of Mt. Con mine, was appointed assistant general superintendent of mines succeeding Mr. Ronouard. Mr. Bigley succeeds **H. J. Rahilly** who will report to the mining dept. in New York.

R. M. Belliveau has been promoted to general superintendent of the Mesabi iron range mines, Cleveland-Cliffs Iron Co.

Walter S. Bannister is now mine engineer, Munro mine, Canadian Johns-Manville Ltd., Matheson, Ontario. He was formerly layout engineer, Kerr-Addison Gold Mines, Ltd., Virginiatown, Ontario.

A. H. Barrios has been transferred to the Andes Copper Mining Co. at Porterios, Chile in the capacity of mining foreman, from the Anaconda Copper Mining Co., Butte mines. He can be reached at Andes Copper Mining Co., Chanaral, Chile.

A. H. BARRIOS

James E. Collord was awarded a bronze medal by the Carnegie Hero Fund Commission for his actions following a dynamite explosion on Brundage Mt.

Alden P. Colvocoresses, ventilation engineer, Magma Copper Co., Superior, Ariz., has entered active duty with the Corps of Engineers. He will be stationed in Washington, D. C. with the intelligence section of the Army map service.

John D. Cooner is chief, mining branch, anthracite research laboratory, U. S. Bureau of Mines, Schuylkill Haven, Pa.

Waldemar F. Dietrich, senior member of Dietrich, Morse & Associates, consulting engineers, Sacramento, has been appointed as chief of the rare and precious metals branch, minerals div., Bureau of Mines, U. S. Dept. of Interior.

John Dahm recently joined the Gulf Oil Corp., Casper, Wyo., as geologist. He had been instructing at A&M College of Texas, College Station, Texas, in the dept. of geology.

Kuno Doerr, Jr. was reelected vice chairman directing the smelting div., Montana Safety Council. Mr. Doerr is manager of the East Helena plant, American Smelting & Refining Co.

Laning Dress is now employed with Roberts & Shaefer Co., Chicago as assistant to executive vice-president.

Charles W. Fleming is now employed as a mine engineer by the American Smelting & Refining Co., Santa Barbara, Chihuahua, Mexico.

WILLIAM T. FERGUSON

William T. Ferguson, former assistant sales manager, has become sales manager, Goodman Mfg. Co., Chicago.

William H. Goodhue is presently employed as an engineer with Peter Kiewit Sons Co., Ross Dam, Rockport, Wash.

Oscar A. Glaeser, industrial relations engineer, U. S. Smelting Refining & Mining Co., has been named assistant to the vice-president and general manager of western operations. **Byron E. Grant** has been made assistant manager of western mines.

Ralph K. Gottshall was appointed assistant to the president, Atlas Powder Co., Wilmington. He was previously assistant general manager of the explosives dept.

William F. Guenther has assumed the duties as head of the exploration dept., United Clay Mines Corp., Trenton, N. J.

Charles Hillery is now mining engineer for the West Virginia Coal & Coke Corp., Omar, W. Va.

James S. Hastings is presently employed as a mining engineer trainee for the Oliver Iron Mining Co., Virginia, Minn.

William O. Jenkins, engineer in charge of air cleaning products div., Whiting Corp., Harvey, Ill. has been temporarily assigned to Los Angeles. He is developing and designing equipment for iron foundries to bring them into compliance with the Los Angeles smog laws.

Walter Larsh, who recently retired as general manager of the Nevada operations of the Kennecott Copper Corp., has been retained in a consulting capacity. His headquarters will be at McGill, Nev.

Virgil Lessels has accepted the position of metallurgist with the Chile Exploration Co., Chuquicamata, Chile. He had been chief concentrating testing engineer, International Smelting & Refining Co., Tooele, Utah.

Charles A. Mitke, who has been developing mining properties in the

CHARLES A. MITKE

Philippines since the end of World War II, recently returned from a three months' investigation of manganese and chrome deposits in India and Turkey. He may be contacted at the Bankers Club, 120 Broadway, New York, N. Y.

Thomas S. Lovering was elected acting president of the Geological Society of America.

Joseph L. McCluggage is now assistant mining engineer, Anglo-Oriental Ltd., Koala Lompur, Malayan Federation.

Donald H. McIntosh is now superintendent of the western section, research dept., American Smelting & Refining Co., Salt Lake City.

H. S. McQueen is now associated with the Salt Dome Production Co., Houston, as executive vice-president and chief geologist. He was formerly chief geologist for Alcoa Mining Co., New York.

W. D. McMillan, mining engineer with the U. S. Bureau of Mines is now located at Denver.

Albert B. Needham, chief of the Bureau of Mines, mining div. for Region V, Minneapolis, has been appointed to head a team that will determine the feasibility of Federal aid to private industry for exploiting promising mineral deposits in the upper midwest essential to the defense program.

Bruce C. Netschert has accepted the position of commodity-industry analyst, foreign minerals region, U. S. Bureau of Mines, Washington, D. C. He was formerly assistant professor, dept. of business and economics, University of Minnesota, Duluth.

Edmund Newton recently became chief engineer of U. S. Ferro Metals Corp., Deming, N. Mex. He was previously designing engineer with Western-Knapp Engineering Co., New York, N. Y.

EDMUND NEWTON

John Naylor has finished his contract with Volcan Mines Co., Ticlio, Peru, as chief engineer. He is now specializing in mine and other types of surveys in the Lima, Peru area.

Desmond de V. Oxford, chief surveyor, has been made senior standards engineer, Nchanga Consolidated Copper Mines Ltd., Chingola, N. Rhodesia.

Alan P. Ploesser is now employed as a design engineer by the U. S. Gypsum Co., Chicago. He had been connected with the Benguet Consolidated Mining Co., Baguio, P. I.

L. F. Pett has been appointed general superintendent of mines for the Utah Copper Div., Kennecott Copper Corp. He was formerly superintendent of mines.

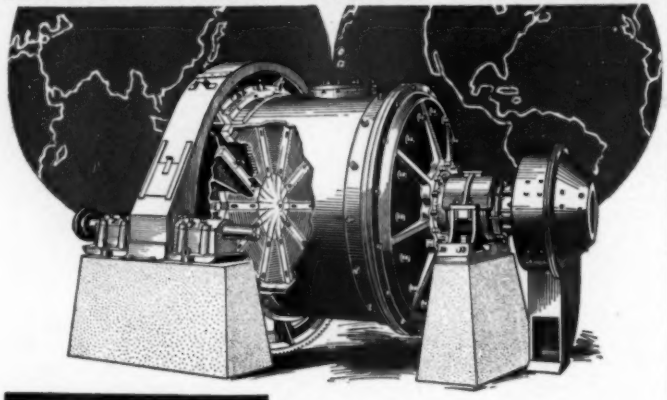
Roland D. Parks, M.I.T., has been appointed as associate of Behre Dolbear & Co., New York. **F. Blondel** has been made foreign consultant in Paris and **Tadishiro Inouye** consultant in Tokyo.

Lute J. Parkinson, mining consultant, was presented with the Colorado School of Mines Distinguished Achievement Award. For the past five years he has been mining consultant for the Anglo-Chilean Nitrate Corp. and the Lautaro Nitrate Co., Ltd., Antofagasta, Chile.

H. W. Rembold has been promoted to assistant superintendent of drilling, Cleveland-Cliffs Iron Co., Michigan.

Desmond C. Stepehens has taken a position with Eldorado Tennant Creek Ltd., Northern Territory, Australia.

MARCY MILLS GIRDLE THE GLOBE



584 OUTSIDE U. S. A.	
Alaska	11
Canada	148
Mexico	39
Cuba	9
Latin Amer.	127
Europe	90
Africa	31
Far East	42
Philippines	37

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● Permit us to present field records which substantiate these statements.

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THE Mine & Smelter SUPPLY COMPANY

Ralph Adair, until recently chief engineer of the minerals research laboratory, North Carolina State College, Asheville, N. C. has opened a consulting office at Bull Mt. Rd., Asheville, to specialize in the beneficiation of nonmetallic minerals.

William G. Richards, officer engineer, Ingersoll-Rand Co., Salt Lake City is to be located at the San Francisco office. He is presently familiarizing himself with new developments in the company's products.

C. T. Ulrich, chairman of the executive committee of Kennecott Copper Corp., New York, N. Y. is retiring but will continue as a director of the firm.

James H. Robins, president of the American Pulley Co. is now a vice-president of the Franklin Institute of the State of Pennsylvania, Philadelphia.

ROBERT F. MEHL

Robert F. Mehl, director of the metals research laboratory and head of the dept. of metallurgical engineering, Carnegie Institute of Technology has been named head of the top government advisory board on metallurgy.

William H. Munds is now with the U. S. Bureau of Mines at Joplin, Mo., where he is doing mine examination and evaluation work. Mr. Munds was formerly with the Natural Resources Section of SCAP stationed in Japan.

Scott L. Burill is mill metallurgist at the McGill, Nev., concentrator of Kennecott Copper Corp. He was formerly at Anaconda, Mont., employed by Anaconda Copper Mining Co.

Renato De Sena Zoppis may be reached at Via Sernesi 10, Bolzano, Italy. He was doing mining and geological consulting work for the State Secretary's Office of the Dominican Republic.

V. E. MacDonell has returned from the Pacific where he was stationed on Guam and is now associated with the American Cyanamid Co., New York, N. Y.

Philip E. Rosen is now with the Quemont Mining Corp., Ltd., at Noranda, Que. He was formerly at Torbrit Silver mine, Alice Arm., B. C.

Donald C. Sewall has moved from Menasha, Wis., to become assistant quarry engineer, U. S. Gypsum Co., Sweetwater, Texas.

John Douglas McKichan recently resigned as ventilation engineer for Britannia Mining & Smelting Co., to accept the position of ventilation engineer with the Industrial Health Laboratory of the Health Div. of the Dept. of National Health and Welfare, Ottawa, Ont.

LATHAM B. GRAY, JR.

Latham B. Gray, Jr., mining engineer with the Bethlehem Collieries Corp. (W. Va.), Idamay, W. Va., was recently called to service in the Armed Forces.

M. G. McGrath, formerly metallurgical engineer with the U. S. Atomic Energy Commission has become associated with the Vitro Chemical Co., Salt Lake City, as vice-president. Vitro Chemical Co. has taken over the former Kalunite plant at 600 W. 33rd South, Salt Lake City.

Joseph A. Jagunich is now mining engineer trainee with the Oliver Mining Co., Hibbing, Minn.

Burhl Dykhouse, superintendent, Silver King, Prescott, Ariz. is now working at Mount Union mine.

Frank C. Foley, district geologist, U. S. Geological Survey, Madison, Wis., has been appointed geologist and head of the Div. of Groundwater Geology and Geophysical Exploration, Illinois State Geological Survey.

John G. Munson has resigned as vice-president, raw materials, U. S. Steel Corp. of Delaware, now merged with U. S. Steel Corp. For a time he will service the company in an advisory capacity.

Robert J. Linney is now operating manager, Reserve Mining Co., 1125 Guildhall Bldg., Cleveland, Ohio. Mr. Linney has been district manager of Republic Steel Corp. at Port Henry, N. Y., for many years.

Vernon B. Pratt, mining engineer, formerly of Lake City, Colo., can now be reached at Box 233, Ray, Ariz.

Thomas S. Cochrane graduated last spring from the University of British Columbia and is now doing post graduate work for his master's degree in coal mining engineering at the University of Washington at Seattle.

Frank J. Boyce of the Virginia Technical Station, Blackburg, Va., has been recalled to active duty in the Navy Reserve and is now stationed on Guam.

Warren P. Charnack and **Charles E. Lundin** will each be awarded $100 prizes for papers by graduate student associates entered in the Institute's 9th National Student Prize Contest. Mr. Charnack's paper was entitled, "The Martensite Phase" and Mr. Lundin's, "Corrosion—Fatigue of Alloy Steels." Both papers were entered by the Chicago Section.

For papers by undergraduate student associates: A prize of $100 for a paper entitled, "An Investigation of the Miscibility Gap in the System Copper-lead," to **Donald Rich,** entered by the Pittsburgh Section. A prize of $100 for a paper entitled, "A Study of the Properties of Drilling Fluids Containing Certain Natural Organic Colloids of Iranian Origin," to **George Tchilingarian,** entered by the Southern California Section. A prize of $100 for a paper entitled, "Casting Stainless Steel Tensile Bars in Ceramic Molds," to **Philip Frederick,** entered by the Chicago Section.

At the Welcoming Luncheon, Monday, 12:15 pm, Feb. 19, the prizes in the Institute's 9th National Student Prize Contest will be awarded.

Charles W. Yetter has become general manager of the Chesapeake Coal Co. and vice-president and general manager of Lake-Land Coal Co., Cleveland. Mr. Yetter had organized and had been superintendent of the Union Carbide & Carbon Corp. strip coal mine in Dexter City, Ohio.

E. C. Van Biarcom, superintendent of the zinc plant at the Anaconda Copper Mining Co., Great Falls, Mont., smelter, has resigned and accepted a position with Singmaster & Breyer, New York, consultants in metallurgy. **Thomas K. Graham** has been appointed superintendent of the electrolytic zinc plant. He was formerly assistant superintendent.

Thomas F. Edson has been appointed executive assistant to the president, Victor Chemical Works, Chicago. Mr. Edson had been superintendent of operations at Silver Bow, Butte.

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Carl H. Samans, associate director of research, Standard Oil Co., Chicago, has been made representative of the Chicago Section, AIME, to the Chicago Advisory Committee of Engineering Societies Personnel Service, Inc.

S. Power Warren has temporarily discontinued his consulting work and returned to the employ of the government in a capacity with the evaluation branch of the production and expansion div., Defense Minerals Administration. He may be contacted at Falls Church, Va.

James R. Young, mining engineer, has joined the engineering dept., Lake Mining Co., Biwabik, Minn.

Obituaries

Charles Preston Anderson (Member 1950) has died. Born in Pulaski, Va. in Feb. 1888, Mr. Anderson attended Princeton Academy. At the time of his death he was president of the Mary Frances Coal Co., Ingram Branch, W. Va.

John C. Gaul (Member 1917), retired, died on Oct. 23, 1950. Mr. Gaul was born at Calumet, Mich. and attended high school there. In 1905 he attended the University of Notre Dame, Michigan College of Mines in 1907, and graduated from the Colorado School of Mines with the degree of E.M. in 1912. He was employed as a miner, shift and assistant foreman in various mining companies. In 1915 he joined the Anaconda Copper Mining Co. at the Berkeley mine. While serving as foreman he was advanced to the post of assistant general superintendent of mines. He retired from this position in 1945.

Irvin Gladstone (Member 1943) died on May 9, 1950. Mr. Gladstone was born in New York City on Apr. 18, 1916. He was educated at Brooklyn College, George Washington University, and graduated from Harvard with the degree of M.A. in 1941. Following graduation he joined the U. S. Geological Survey, Washington, D. C. as a junior geologist. He remained with the USGS for several years in Washington, D. C. and Metaline Falls, Wash. In 1946 he joined the U. S. Smelting Refining & Mining Co., Hanover, N. Mex.

Joseph J. Haberthier (Member 1945) died on August 27, 1950. He was born at Modoc, Kansas and graduated from the Missouri School of Mines & Metallurgy, Rolla, with the degree of B.S. in mining engineering in 1921. He was employed in various mining capacities by several companies and in 1929 went into business for himself. In 1943 he joined the Kaiser Shipyards, Richmond, Calif., as an assistant engineer. He remained on the west coast several years and in 1946 moved to Bartow, Fla.

John Robert Hallock (Member 1947) died in a mill accident on Oct. 15, 1950. Born in Denver in 1924, he graduated from the Colorado School of Mines in 1949 with the degree of Met. E. He entered college in 1942 but was in the Army during World War II and returned in 1946. Following graduation he was employed by the Idarado Mining Co., Ouray, Colo. as a mill helper.

George H. Harbordt (Member 1937) died on Oct. 19, 1950. Mr. Harbordt was born in St. Louis but most of his life was spent working for various mining companies in South America and Mexico. In 1917 he joined the Cia Minerales y Metales as superintendent of the Cerralvo smelter. He was made superintendent of the Torreon and Monterrey smelters for the same company. For two years he was general smelter superintendent for all plants of Cia Minera de Penoles, Nueva Leon, Mexico. In 1925 he was made general manager.

Charles W. Johnston (Member 1913) died on Oct. 24, 1950. Born at Philadelphia, he graduated from M.I.T. with the degree of S.B. in mining engineering in 1905. Several years were spent as an engineer with a few mining companies. In 1911 he joined the Raven Copper Co., Butte, and in 1915 became manager for the Virginia Smelting Co.

Virgil R. D. Kirkham (Member 1926) has died. He attended the University of Washington, receiving a B.S. in geology, in 1920; University of Idaho, M.S. in geology in 1922 and did graduate study at the University of Chicago for one year. Following graduation he was employed by the U. S. Geological Survey and then was an instructor in geology at the School of Mines, University of Idaho. In 1930 he joined the Pacific Exploration Co. as economic geologist. A year later he became associated with the Michigan Pacific Oil & Gas Co., Saginaw, Mich. as vice-president and chief geologist.

William Bradford McKinlay (Member 1902) recently died. Mr. McKinlay was born in New York City and attended local schools, graduating as engineer of mines from Columbia School of Mines in 1895. Several years were spent in New Mexico, Ecuador, West Indies, and Porto Rico. In 1925 he was a mining engineer in Colorado and then came east. He was editor of the Engineering Index in 1929 and wrote various articles for mining journals.

C. Quinby Schlereth (Member 1936) died on Nov. 10, 1950. Born at Denver in 1884, Mr. Schlereth graduated from the Colorado School of Mines with the degree of engineer of mines in 1906. After graduation he was assayer to the chief engineer, Cia. Minera de Penoles S.A., Ojuela Durango, Mexico. He remained with that concern in various capacities as general manager, general superintendent and in 1918 was made general superintendent, mining dept. and a member of the executive committee. He was general manager of the San Francisco mines of Mexico Parral, in 1923 and in 1924 joined the Potosi Mining Co., Chihuahua as general manager. He then went into private consulting practice at Denver.

Morris Harley Wilcox (Member 1943) died in March 1950. Mr. Wilcox was graduated from the University of Idaho with the degree of B.S. in 1928. For nine years he was employed by the Anaconda Copper Mining Co. as an analytical chemist and in 1937 was made assistant research engineer for the same firm. He became assistant superintendent of concentration in 1941 and held this position for several years.

Necrology

Date Elected	Name	Date of Death
1943	Herman G. A. Cowes	Oct. 1950
1940	Harry V. Long	Oct. 16, 1950
1941	Abraham S. Hersov	Feb. 1949
1937	Richard Stevens Eakridge	Dec. 4, 1950
1938	Charles W. Howbert	Dec. 4, 1950
1903	George B. Rodgers	Sept. 10, 1950
1941	Charles Morgan	May 20, 1950
1911	Arthur B. Shutts	Nov. 30, 1950
1931	Bert E. Sandell	Nov. 14, 1950

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— Coming Events —

Feb. 1, Colorado Mining Assn., annual convention, Denver.

Feb. 2, Illinois Conference on Industrial Research, annual conference Armour Research Foundation of Illinois Institute of Technology, Technology Center, Chicago.

Feb. 2, AIME, Florida Section, Lakeland, Fla.

Feb. 5, AIME, Mexico Section, American Club, Mexico City.

Feb. 5, ASTM, Cleveland District, Cleveland.

Feb. 6, Society for Applied Spectroscopy, 6 pm dinner, Tosca's; 8 pm meeting, Socony-Vacuum Training Center, New York, N. Y.

Feb. 7, AIME, Chicago Section, Chicago Bar Assn., Chicago.

Feb. 7, Bituminous Coal Research Institute, Inc., annual meeting, Deshler-Wallick Hotel, Columbus, Ohio.

Feb. 12-16, Industrial Personnel Testing Institute, Rensselaer Polytechnic Institute, Troy, N. Y.

Feb. 15, Northwest Mineral Industry Institute, University of Washington, Seattle.

Feb. 18-22, AIME, annual meeting, Jefferson Hotel, St. Louis. Metals Branch session to be held at the Statler Hotel.

Feb. 19, AIME, Detroit Section.

Feb. 20, ASTM, Philadelphia District, Philadelphia.

Feb. 20-22, American Concrete Institute, annual convention, St. Francis Hotel, San Francisco.

Feb. 21, AIME, Western Section, Open Hearth Committee, Iron and Steel Div., Los Angeles.

Feb. 21, National Open Hearth Committee, Southwestern Section, Lennox Hotel, St. Louis, Mo.

Feb. 27-28, AIME, Los Angeles Section and Mining Committee, Los Angeles Chamber of Commerce.

Mar. 5, AIME, Florida Section, Lakeland, Fla.

Mar. 5-7, Hydraulic Institute, quarterly meeting, Santa Barbara Biltmore Hotel, Santa Barbara, Calif.

Mar. 5-7, Manufacturers Standardization Society of the Valve and Fittings Industry, annual meeting, Commodore Hotel, New York.

Mar. 5-9, ASTM, spring meeting and committee week, Cincinnati.

Mar. 6, Society for Applied Spectroscopy, 6 pm dinner, Tosca's; 8 pm meeting, Socony-Vacuum Training Center, New York, N. Y.

Mar. 11-14, American Institute of Chemical Engineers, regional meeting, Greenbrier, White Sulphur Springs, Va.

Mar. 13-16, National Assn. of Corrosion Engineers, conference and exhibition, Hotel Statler, New York.

Mar. 19-23, Conference on Industrial Personnel, Dept. of Industrial Engineering, Columbia University, New York, N. Y.

Coming Events

Mar. 21-22, Combustion of Industrial Fuels, conference; sponsorship of College of Engineering, University of Michigan, Ann Arbor.

Mar. 22, ASTM, Philadelphia District, Philadelphia.

Mar. 26-27, Natural Gas Engineering Lectures, University of Kansas campus, Lawrence, Kan.

Mar. 31-Apr. 2, AIME, Blast Furnace, Coke Oven and Raw Materials and National Open Hearth Steel Conference, William Penn Hotel, Pittsburgh.

Apr. 2-4, 1951, AIME, Open Hearth and Blast Furnace, Coke Oven and Raw Materials Conference, Iron and Steel Div., Statler Hotel, Cleveland.

Apr. 3-5, ASME, spring meeting, Atlanta-Biltmore, Atlanta.

Apr. 4-6, Midwest Power Conference, Sherman Hotel, Chicago.

Apr. 15-18, Scientific Apparatus Makers Assn., annual meeting, Greenbrier, White Sulphur Springs, W. Va.

Apr. 16-18, American Society of Lubrication Engineers, national convention, Bellevue-Stratford Hotel, Philadelphia.

Apr. 23-26, American Foundrymen's Society, annual convention, Buffalo, N. Y.

Apr. 25-26, Metal Powder Assn., annual meeting, Hotel Cleveland, Cleveland.

Apr. 30-May 4, Materials Handling Exposition, International Amphitheatre, Chicago.

Apr. 30-May 11, British Industries Fair, annual industrial show, Olympia and Earls Court, London; Castle Bromwich, Birmingham.

May 7, AIME, Florida Section, Lakeland, Fla.

May 7-11, Greater New York Industrial Show, 71st Regiment Armory, New York, N. Y.

May 9-11, Engineering Institute of Canada, annual meeting, Mount Royal Hotel, Montreal.

May 13-16, American Institute of Chemical Engineers, regional meeting, Hotel Muehlebach, Kansas City, Mo.

May 14-17, American Mining Congress Coal Mining Convention & Exposition, Auditorium, Cleveland.

May 23-24, American Society for Quality Control, annual convention, Hotel Cleveland, Cleveland.

June 11-15, ASME, semi-annual meeting, Royal York, Toronto, Canada.

June 18-22, ASTM, annual meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

Sept. 16-19, American Institute of Chemical Engineers, regional meeting, Sheraton Hotel, Rochester, N. Y.

Sept. 25-28, ASME, fall meeting, Minneapolis.

Oct. 3-5, AIME, Petroleum Branch, fall meeting, Oklahoma City.

Oct. 8-12, National Hardware Show, Grand Central Palace, New York, N. Y.

Oct. 9-12, Scientific Apparatus Makers Assn., midyear meeting, recorder-controller section, Seaview Country Club, Absecon, N. J.

Oct. 11-12, AIME, fuels conference, Roanoke Hotel, Roanoke, Va.

Oct. 15-17, AIME, Institute of Metals Div., fall meeting, Detroit-Leland Hotel, Detroit.

Oct. 15-19, National Metal Congress & Exposition, Detroit.

Oct. 22-24, Metal and Nonmetallic Mining Convention, Biltmore Hotel, Los Angeles.

Oct. 25-26, AIME, Los Angeles Section, fall meeting, Los Angeles.

Oct. 29-Nov. 3, AIME, fall meeting, Mexico City.

Nov. 28-30, Scientific Apparatus Makers Assn., midyear meeting, industrial instrument, laboratory apparatus, laboratory equipment, optical, nautical, aeronautical, and military instrument sections, Hotel New Yorker, New York.

Dec. 6-8, AIME, Electric Furnace Steel Conference, William Penn Hotel, Pittsburgh.

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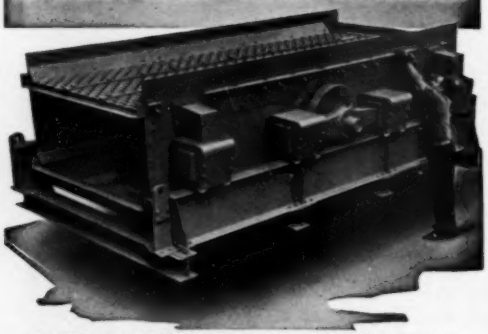

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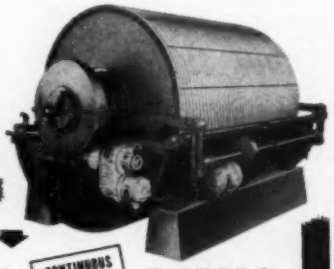

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ADMISSIONS COMMITTEE

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Institute members are urged to review this list as soon as the issue is received and immediately write the Secretary's Office, night message collect, if objection is offered to the admission of any applicant. Details of the objection should follow by air mail. The Institute desires to extend its privileges to every person to whom it can be of service but does not desire to admit persons unless they are qualified.

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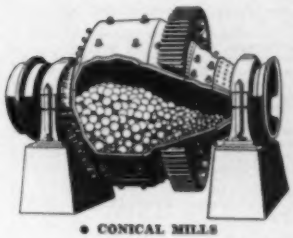

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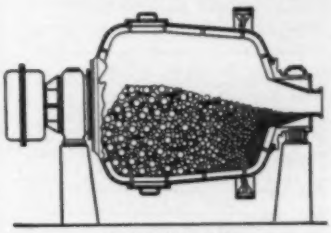

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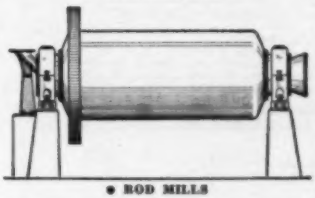

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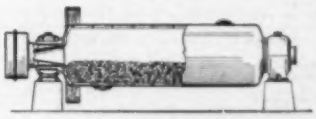

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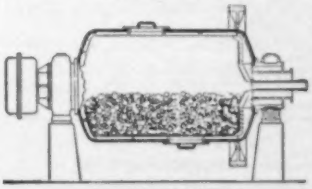

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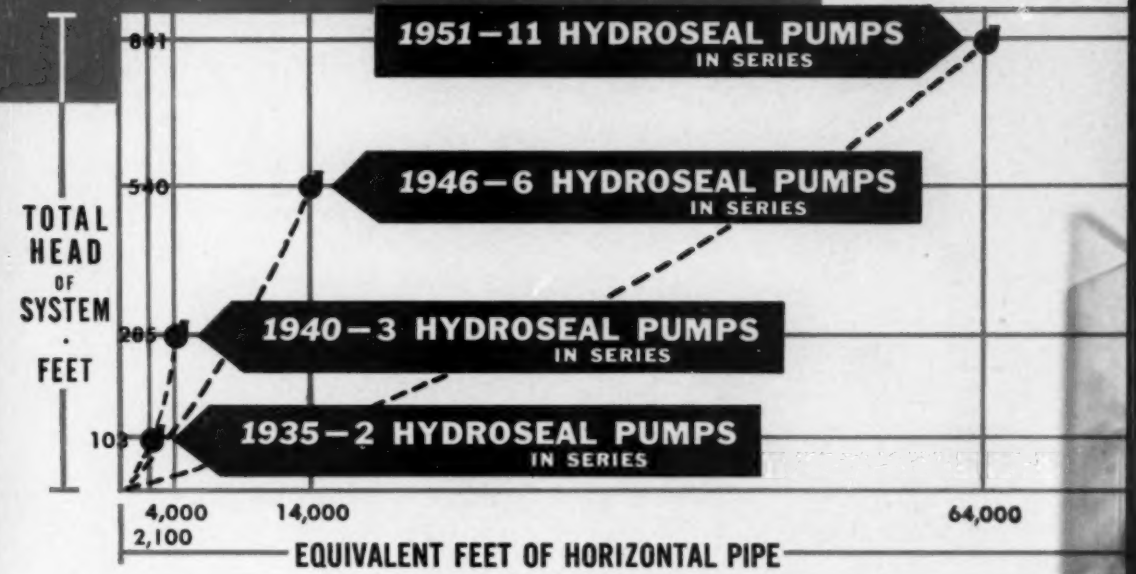

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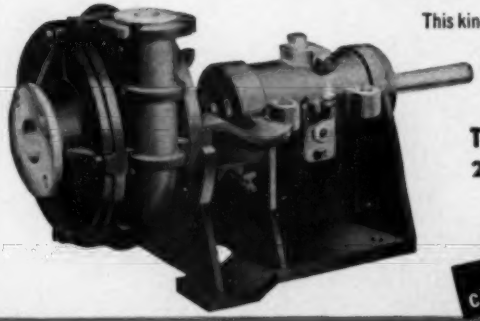

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There's an important connection between Your Production and Our Research

Because of the M.S.A. Research Laboratory, a lot of miners are going to keep on living. The primary purpose of M.S.A. research is to constantly expand and improve the means of combating worker hazards.

This aim alone completely justifies the activity . . . but there is another benefit, also because of the M.S.A. Research Laboratory, a lot of extra production will flow from the nation's mines. The improved safeguards developed by the program let the miner concentrate on his *work*. By reducing the human cost of the operation—the dollar cost drops, too. The money spent for safety, like bread cast upon the waters, returns many-fold.

Mine management today is concerned with expanding and extending mine safety which further expands and improves production, to combat sky-rocketing costs. M.S.A. products, with the extra safety added by research, provide a proven means of reaching these goals.

MINE SAFETY APPLIANCES COMPANY
BRADDOCK, THOMAS and MEADE Sts. . . . PITTSBURGH 8, PA.

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When you have a safety problem, MSA is at your service. Our job is to help you.

MSA
SAFETY EQUIPMENT HEADQUARTERS